BANANA BOARD RESEARCH DEPARTMENT

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ANNUAL REPORT

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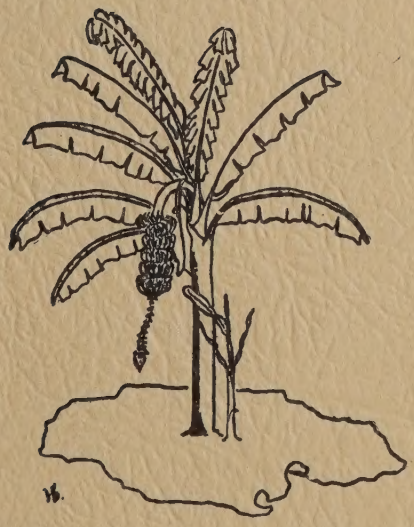

10 SOUTH AVENUE, KINGSTON GARDENS
KINGSTON, JAMAICA.

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December, 1960

BANANA BOARD RESEARCH DEPARTMENT

"Fontabelle",
10 South Avenue,
Kingston Gardens,
Kingston, Jamaica, W.I.
17th October, 1960.

The Chairman,
Banana Board.

Dear Sir,

I have pleasure in submitting the Annual Report of the Research Department for the year 1959.

Yours faithfully,
(Sgd.) R. LEACH,
Director of Research.

BANANA BOARD RESEARCH DEPARTMENT
ANNUAL REPORT

1959

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I. INTRODUCTION

Oil spraying of bananas for control of leaf spot had decreased towards the end of 1958, due to phytotoxicity of the oil, especially in areas affected by the severe drought which occurred once more in the important banana growing parish of St. Mary. Resulting from the trials carried out by the Research Department that year, a different oil was used by the All Island Banana Growers' Association in its spraying organisation, to the satisfaction of growers in 1959. The new oil has considerably improved the prospect of attaining more widespread control of leaf spot throughout Jamaica. Its success has been particularly opportune in view of the low standard of efficiency to which so much Bordeaux spraying has fallen recently. Leaf Spot still remains the major potential threat to the banana industry.

Aerial oil-spraying made remarkable progress during the year when trials demonstrated that leaf spot can be controlled on bananas growing under tall coconut palms by oil spraying from fixed-wing aircraft flying above them. The main trial was carried out by aircraft using centrifugal atomisers, after which a later trial showed that the boom type of spraying equipment can attain the same results. A few estates had contracted for this high level spraying before the end of the year. The value of this form of spraying is great in Jamaica where so many bananas are grown under coconuts which prevent an aeroplane flying low over the bananas in the accustomed manner used on the irrigated plains, where leaf spot is now practically eradicated.

The Department was fortunate to obtain on its staff during the year the services of a nematologist who had just been working for two years in Central America on the same nematode disease as that which had been rediscovered on bananas in Jamaica in 1957. The work initiated by the Research Department on the use of nematocides was continued by the Plant Pathologist. The nematologist mainly devoted his investigations towards finalising his work on evolving a method for obtaining clean "seed", with the primary object of establishing disease-free nurseries. A general survey was made of the nematode problem affecting bananas in Jamaica.

The Chemical Division had a difficult year owing to the procrastination of builders employed to erect an extension to the laboratory adjoining larger, new offices nearby. The recent work on "premature yellowing" has done much to stimulate interest in the increased use of potash fertilizers, since growers are now beginning to distinguish symptoms of this nutritional disorder from those of severe leaf spot. The long term investigations into soil and foliage analysis have continued to illustrate the complexity of interpretation in results obtained from banana plantations on different soil types, the banana plant being morphologically somewhat unusual and being particularly responsive to variations in soil moisture conditions.

The Agronomist has found that the variation in the growth rate of ratoons at different altitudes is unaffected by the time of year at which the crop suckers first appear.

Storage disease investigations were mainly concerned with studies on the mode of infection of banana fruit by the fungus causing non-latent anthracnose and Santa Marta stem end rot, together with tests for controlling these diseases by dipping the fruit in fungicide solutions or suspensions prior to shipment. This work was carried out largely in the Research Department's cool store and ripening rooms.

Members of the staff are fully aware of the debt of gratitude owed to all those growers who have so kindly provided much assistance in various ways throughout the year, enabling the field work to be decentralised. The help given by the statisticians of the Ministry of Agriculture and the Sugar Manufacturers' Association is again gratefully acknowledged.

The Soil Chemist was on overseas leave from 8th July, 1959, to October, 1959.

II. REPORT OF CROP PHYSIOLOGIST (E. A. TAI)

The Crop Physiologist attended a meeting of the American Society for Horticultural Science, Caribbean Region, in June, 1959, and took part in a short symposium on the effect of climate on horticulture by leading a discussion on the effect of altitude on the growing period of Lacatan bananas. Both Soil Chemist and Analyst were on leave from July to October and Mrs. S. F. Williams who had been the department analyst up to March, 1957, was taken on to supervise the laboratory in their absence. For about two months Mr. L. A. Wilson, the 1957 Banana Board Scholar, rendered valuable assistance in the Analyst's laboratory.

The availability of areas for field experimentation was reduced by the changes in policy of growers on whose holdings plots were laid out; several of these resorted to cut-back in banana acreages and a number of field experiments ended prematurely. The dependence on co-operating banana growers for land on which to locate field experiments is inevitable as the Department does not exercise direct control over land anywhere; the likelihood, therefore, of any field experiment layout being satisfactorily maintained until the completion of observations according to plan must be the subject of a calculated risk. Of seven individual field experiments continued from 1957 four were brought to a premature end, one was terminated according to schedule and the others were still in progress at the end of the year; two were brought forward from 1958 but one (initiated in November) lasted only till January, 1959. There were eleven new ones actually initiated in 1959; plans prepared for two others were not put into effect because of late changes on the part of growers.

In the second quarter of 1959 the decision was taken by the Director to revise the research programme of the section and have field projects dealing with pruning to control crop succession transferred to the Agronomist. The Physiologist should undertake investigations on (a) foliage analyses as a basis for a study of nutritional requirements, (b) sucker production in relation to the need for overcoming backward sucker development, (c) the effect of oil spraying on (i) the tissues of the pseudostem in relation to sheath splitting (ii) the tissues of the finger stalk in relation to mechanical damage, (d) openhandedness, (e) premature yellowing. Accordingly some time was devoted to preparing up-to-date accounts for handing over a number of projects to the Agronomist and revising the schedule of experiments planned. The result of experiments on timing of crop production are, therefore, given in the Agronomist's report.

A. Nutrition of the Banana Plant

(i) **Foliar analyses:** Monthly collections of leaf samples from three sites of known performance — two good, one poor — were continued throughout the year for determination by the Analyst of the contents of the so-called major elements. Because of laboratory limitations it did not prove possible to carry out analysis of all the samples collected in 1959 before the end of the year; a discussion of the results obtained to date is given in the report of the Analyst and plans were made, however, to present a special account of the investigations as soon as the analyses are completed.

Leaf samples were also collected from plots of fertiliser experiments terminated during the year; leaves which had unfurled for 18 to 22 days were used to provide the samples. Analyses of these are to be correlated with yield and other data from the respective experiments to establish possible connections between fertilizer applications, leaf composition and yield performance of bananas.

(ii) **Nutritional disorders:** Plans were laid for ad hoc investigation of abnormalities in banana plants wherever they might occur with a view to identification of nutritional disorders in the field. Morphological and histological examination of plants, chemical analysis of the leaves and the soil are expected to be the principal methods applied in this project.

An interesting and relatively rare condition in which excess potash was limiting growth of young bananas was discovered by these means. The plants exhibited severe chlorosis accompanied in instances with marginal scorch and interveinal necrosis; chemical analysis revealed very high contents of potash in leaf tissue and the soil. It transpired that the area was the site of an old dump for ashes of burnt coconut husks and had apparently accumulated a toxic concentration of soluble potash.

Scorching of the leaves of germinating banana suckers on the St. Catherine plains was traced to the effect of soluble fertilizer placed in contact or very close to the suckers in furrows for mechanical covering. It occurred at a time when soil moisture was low and the "burning off" of the young roots and injury of other tender tissue of the shoots suggested plasmolysis of the cells of the plants by a highly concentrated soil solution. The condition was remedied by adequate irrigation.

(iii) **Fertilizer trial:** The experiment laid down in November, 1958, on Deepdene Clay in St. Catherine to study the effects of phosphate application under conditions of low pH and extremely low available soil phosphate was brought to an end in January when the owner of the holding decided to abandon the growing of bananas. There had been only one application of the experimental treatments and no observations had yet been recorded.

B. Sucker Production

(i) **Gibberellic acid:** In an experiment conducted at the Banana Breeding Station, Bodles, in March and April, 1959, varying concentrations of Gibberellic acid in lanolin

paste were applied to young buds on a Lacatan plant. The amount of paste was 100 mg. in each instance and the concentrations were 0.0125%, 0.125%, 0.325%, 0.625%, 1.25%. Treated buds elongated up to 1 inch within 16 days whereas comparable buds which were not treated failed to show any growth; the elongation was not accompanied by the customary amount of swelling normally associated with growth of banana buds. At the time it appeared also that there was more rapid growth of the basal "peepers" on the plant which received the treatment with Gibberellic acid.

This observation suggested the possibility of using Gibberellic acid to stimulate rapid production of suckers in banana and so provide a means of multiplying clones within a short time. To test this a trial involving the application of Gibberellic acid to Lacatan banana suckers prior to planting was initiated. Uniform sword suckers with a corm of approximately 6 inches diameter in each case were selected for the trial. They were prepared by removal of "cabbage" down to 3 inches above the growing point and treated with Gibberellic acid according to the schedule set out in the Appendix Phys. 1., then planted out in the field in three randomised blocks with two suckers to each plot.

Planting was done in July during dry weather and although the area was irrigated by flooding the first growth did not occur until after 6 weeks. Subsequently gaps were supplied to ensure a full population and it transpired that the death of suckers occurred only where the higher concentrations of Gibberellic acid had been used. Growth in the field up to December appeared from visual inspection to be in inverse proportion to the amount of Gibberellic acid applied and the only plants which had produced suckers were the controls in two of the blocks. It would seem reasonable to assume that treatment of banana suckers with Gibberellic acid before planting is unlikely to encourage production of suckers.

(ii) **Pruning schedules:** An experiment to determine the effects of differential pruning schedules on the production of suckers from which followers might be selected for succeeding crops and also the yield of fruit was laid down at Bodles in April, 1959, in a field of ratoons. The area was demarcated into 12 plots of 12 mats each to provide four replications of three main treatments based on the time of selection to the followers:

1. Selection of the first sucker.
2. Selection of the suckers which arise in April or August, the so-called 12-month pruning technique (Tai, 1958.b.)
3. Selection of the follower at bulling of the parent.

Each plot was further subdivided into subjects in which the unwanted suckers were:

A. Removed monthly.

B. Removed only at time of follower selection.

The suitability of the sucker selected as follower in application of Treatments 2 or 3 was decided on consideration of vigour and position on the mat in relation to the parent and also to plants on neighbouring mats. Where suckers exactly satisfying the conditions did not exist their place was taken by "insurance" suckers, as near as possible to what was actually required. The practice of leaving an "insurance" sucker was followed, in any event, until the desired suckers were produced.

The number of suckers produced by each mat was recorded at pruning time; water suckers arising from old heads on the mat were disregarded in making the counts although they were also cut away when pruning was done; regrowths of cut suckers were included, however, as they could not always be distinguished from new suckers. In the case of Treatment 3 only these water suckers were removed up to the time of bulling of the parent. For the purposes of the experiment the recording commenced with banana plants which had not yet shot in April, 1959; a number of these shot in early summer and were followed by another crop before the end of the year.

Results obtained so far and summarised in Appendix Phys. 2 indicate that with more frequent pruning there was a greater number of suckers produced by each mat and the same response was observed with the earlier selection of followers. No significant differences in the number of stems yielded were observed but it would appear that the grading in the plots subjected to 12-month pruning technique were superior to that of the others.

C. Effects of Oil Spraying

The most commonly encountered manifestations of so-called oil phytotoxicity in Jamaica are sheath-splitting, yellowing and "flecking" of the leaf lamina (Leach, 1958.a) and breaking of the petioles; reduction in bunch weight has been reported from other banana

growing countries but has not been definitely established as occurring locally. To obtain positive information on the relation of oil spraying to the conditions listed it was planned to carry out a series of observations on banana plants receiving different spray treatments in different parts of the island.

It has been observed that sheath-splitting and breaking of petioles tend to occur mostly under conditions of low soil moisture and atmospheric humidity. They appear to be associated generally with reduced turgor although a form of sheath-splitting is often seen in young plants which are growing at a very rapid rate. Exploratory observations were made on bananas growing under natural rainfall in St. Mary and on the bananas of the irrigated plains of St. Catherine.

Comparison of measurements of weight, finger length, volume and per cent dry matter of fruit from oil-sprayed plants with the same measurements of fruit from Bordeaux-sprayed and unsprayed plants was commenced at the Caenwood Agricultural Station of the Ministry of Agriculture and Lands in November and it has been planned to extend the making of similar comparisons to other sites where bananas receiving different spray treatments occur near together. Commercially mature bananas of marketable quality were selected for measurements.

With the exception of dry matter content all determinations were carried out in the field immediately after the fruit was reaped. After each bunch was weighed the penultimate hands at butt and tip were detached and used for measuring mean finger length; next the total volumes of the fingers on these hands were measured by displacement of water and the means calculated. For the "dry matter" content samples of 20 fingers were taken at each harvesting of fruit weighed fresh in the field then taken to the laboratory to be sliced into thin discs, dried for at least 2 days at 86°C (to constant weight) and again weighed. The figure obtained as a result does not represent true dry matter content but suffices for purposes of comparison.

The measurements of fruit reaped in November and December appear to support the view that oil-sprayed fruit is likely to be lighter in weight than unsprayed or Bordeaux-sprayed fruit. Insufficient data were collected, however, for a definite conclusion in this respect.

Note It has subsequently been found from the measurements made in 1960 that bunches with the same number of hands and of similar maturity grade taken from oil-sprayed and Bordeaux-sprayed plots did not differ appreciably in weight.

D. **Openhandedness**

Three new field trials were laid down in 1959 — two to test further the observation made previously (Tai, 1958.a) on the effect of timing the application of nitrogenous fertilizer and the other to investigate the possibility of modifying the incidence of openhandedness by varying the irrigation regime. These trials were all located on the irrigated plains of St. Catherine where harvesting of the first crop takes place in a year from planting.

(i) **Timing the nitrogen applications:** The main objective was to observe the extent to which openhandedness might be associated with distribution of the nitrogen quota:

(a) over the entire life of the crop
(b) between planting and flowering bud initiation.

At the same time it was arranged to compare the effects of three nitrogenous fertilizers available to banana growers in Jamaica:

Sulphate of ammonia	21%N
Ammonium sulphate nitrate ..	26%N
Urea	46%N

Details of the layouts are given in the Appendix Phys. 3.

In one of the trials (Openhandedness Field Experiment 4) the bananas were planted in mid-May and first shooting occurred in December. It was apparent from visual observation that greater uniformity in vigour was shown by the plants which received all of the nitrogen by the end of November. All shot plants exhibited considerable length of peduncle between the "throat" and the first hand, a phenomenon usually associated with a high incidence of openhandedness in winter-maturing bananas.

In the other trial (Openhandedness Field Experiment 6) the planting was done at the beginning of August during very dry weather. Initial growth was slow and uneven and extensive supplying was necessary to ensure a full population of the experimental area. The effect of this on the uniformity of development is likely to be appreciable and has been

taken into consideration in application of the experimental treatment with regard to timing of the heavier nitrogen application in relation to anticipated time of occurrence of flower-bud initiation in different plants.

(ii) **Regulating water applications:** A simple trial was laid down to obtain information on the possibility of economic control of openhandedness by manipulation of the irrigation schedule during the active development of the fruit. It was planned that the total quantity of water applied over the length of the crop period should remain constant while the mean effective soil water tension was varied between treatments after shooting commenced. The area selected for the observation is watered by flood irrigation.

The field was planted in July, 1959, and subjected to standard estate irrigation practice of flooding at 3 week intervals for the rest of the year. Plots were demarcated soon after growth of the banana plants commenced but differential irrigation treatment has been deferred until the start of general shooting.

E. Premature Yellowing

The experiment continued from 1958 with different sources of nitrogen and varying frequency of potash application in St. Thomas was concluded in April, 1959, at the end of the "winter" ratoon crop. The symptoms of premature yellowing had almost entirely disappeared from the experimental area and for the first time in the history of the field "commercial" bananas were reaped in any quantity. The yield data obtained showed no significant differences between the treatments as regards numbers of stems or grading but the fruit reaped from the plots receiving 8 applications of potash per annum were noticeably better in appearance than the others.

To determine how this might be related to the experimental treatment leaf samples were collected from each plot in January and April, 1959, for analysis in the laboratory. The results are given in the Appendix Phys. 4 and show clearly that potash uptake was significantly higher with the greater frequency of application of potash fertilizer although the total quantity per annum remained the same.

F. Weed Control in Banana Fields

To investigate the practicability of suppressing weeds in banana fields without damage to young suckers, as frequently seen with normal mechanical weeding by cutlass, hoe or tractor-drawn implements, experiments were undertaken with opaque polyethylene sheeting used as mulch, with the application of chemical sprays as pre-emergence and contact herbicides. There were two trials conducted on plants — one in St. Catherine and the other in St. Thomas — and one trial on ratoons in St. Thomas.

It was found that polyethylene mulching was capable of preventing the growth of most species but did not appear to be successful against nut-grass which had no difficulty in growing through the sheeting. The high initial cost of the material was a factor that could not be ignored in considering its potential use for weed control purposes. Much promise was shown by Simazin and Atrazine as pre-emergence sprays; they suppressed weeds without seeming to affect the banana growth both in plants and ratoons when used at 4 lbs/acre. Dalapon applied at 5 lbs/acre in 35 gallons of water was effective in killing grasses at all stages of their development and Butoxyethyl ester of 2, 4-Dichlorophenoxyacetic acid at ¾ pint in 30 gallons of water to the acre killed broad-leaved weeds. The latter caused some damage to young banana suckers with which it came into contact but no permanent injury occurred on any sucker over a foot high at the time of spraying. Sodium trichloracetate at 9 lbs/acre applied in 30 gallons of water "burnt off" all weeds but the effect was not as lasting as any of the other treatments.

G. Photography

The small photographic darkroom was re-organized to carry out work on behalf of all sections of the Department. One technical assistant was trained in the procedures involved in black and white processing and was responsible for production of over 200 photographs in the latter half of the year. These photographs were placed on file in the Library for reference and copies of a number have been used by specialist officers to illustrate papers for publication.

III. REPORT OF SOIL CHEMIST (C. G. JORDINE)

A. Laboratory

During the year 1959 some 3,500 determinations were done in duplicate on soil samples from various parts of Jamaica. The following analyses have been done in routine

on soil samples — pH, mechanical analysis, moisture equivalent percentage, available potash, available phosphate, sodium chloride content, percentage free calcium carbonate, percentage organic carbon. The soil samples included those taken in the survey of banana fields, those from experimental areas, and those taken from problem areas for advice to growers concerned.

B. Survey of Banana Fields & Soils

In the Annual Report 1957/8 an outline was given of the aim and the procedure of the survey of banana fields and soils. In the present report the objective and practice of the survey is expanded and mention is made of the results expected from it; also, some of the results obtained in the survey on a particular soil type are described.

Little is known about the properties of various soil types on which bananas thrive well. Far more knowledge is needed regarding the soils on which bananas are grown in Jamaica. A soil survey of existing plantations was considered the best way to achieve this purpose. One good example of the benefit from a survey is the work of Dunlap & McGregor (1932) who found that a content of soluble salts greater than 500 p.p.m. was limiting to good banana production.

(i) **Objective and field procedure:** The objective of the survey of banana fields and their soils is to find out the characteristics of good banana land as compared with that on which bananas do poorly, particular emphasis being placed on the physical properties of the soils encountered.

The survey of banana fields and soils began in 1957 in the parish of St. Mary which was chosen because of the great variety of soil types present, the large number of bananas grown there and its proximity to the Research Department's laboratories. The properties or holdings chosen for the survey are those which are well managed and have good control of leaf spot. The fields of bananas on these holdings are placed into one of three categories — good, mediocre and poor — judgment being based on the appearance of the plant and any fruit present. Thus if the greater proportion of bunches in a field consists of those having eight hands or more, the category is good, whereas if five and six hand bunches prevail the category is considered poor. The judgment is also helped by any records of the annual yield of the fields in "count" bunches per acre/annum, namely, under 100 — poor, 100–200 — mediocre, above 200 — good.

Other data collected were: name of property, elevation, name and acreage of each ratoon field, exposure to wind, rainfall for previous year, standard of management and disease control, fertilizers used and quantities applied, banana variety, recorded yields per acre/annum and soil types present.

Internal drainage was partly judged according to the standards of Bonnet and Lopez (1950) by direct observation in the field with the use of an auger.

(1) Well Drained : Soil free draining, with no mottling observed above 20".
(2) Medium Drained : Mottling observed within 10"-20" depth; also a very plastic clay at this depth.
(3) Poorly Drained : Mottling observed within 0"-10" depth; also very sticky clay at this depth.

(ii) **Soil sampling and analyses:** From each field soil samples are taken at two depths 0-9" and 9-18". The number of samples taken from a field depends on the number and extent of the soil types found and also the variation in productivity between one part of a field and another section. Thus more than one soil sample is taken if a field contains more than one soil type, occupying at least one-quarter to one-third of its acreage, or if it has good and poor sections in the field.

(a) **Physical analyses:** Good drainage and tilth are generally considered as essential for the banana. A vital factor, which is partly pedological, is water availability. It has been estimated that the banana plant requires approximately 600 lbs. of water for every 1 lb. of dry matter produced (Pope, 1926). For these reasons the following determinations were undertaken:– (1) Mechanical analysis, by the hydrometer method of Bouyoucos, being indicative of the soil texture; (2) Field capacity — the moisture equivalent percentage being used as an approximate measure of the former. This is an important characteristic of water availability; (3) Permanent wilting percentage or permanent wilting range from the moisture equivalent percentage.

(b) **Chemical analyses:** As it is impossible to do a full range of chemical tests the following important ones were chosen for this investigation: available potash, available

phosphate, pH and percentage organic carbon to all of which reference was made in the Annual Report 1957/8.

(iii) **Results of survey of banana fields and soils:** A survey of banana fields and soils cannot yield the same sort of result as experiments indicating positive or negative responses to application of various fertilizers. It can show what ranges of any particular soil property, e.g., % clay or % free $CaCO_3$ are to be found on areas producing good bananas as compared with areas producing poor bananas.

In 1958 chemical and physical analyses were made of soil samples taken in good, mediocre and poor bearing fields of bananas, situated on several different soil types, throughout a section of the parish of St. Mary. The results were examined statistically without any conclusions being reached regarding the influence of the various factors investigated. It was then decided that greater success might be achieved if the investigations were confined to only one soil type in banana fields where cultural practices were considered adequate yet the growth of the plants varied considerably. The soil type chosen was Fontabelle Clay, the good and mediocre fields being 62% and 38% respectively. The results of analyses made in 1959 were examined statistically (Appendix Chem. 1).

The mean values for the pH, available potash and organic carbon of the good and mediocre fields did not differ greatly. The range of available phosphate however was wide. Some good and mediocre fields to which no phosphate fertilizers had been applied, had values below 30 p.p.m. Significant differences were however observed in the physical properties in the soils of the good and mediocre fields, the better fields tending to have lower percentages of clay and higher percentages of sand. There was hardly any appreciable difference between the percentage conventional silt of good and mediocre fields. The moisture equivalent results were in harmony with the results of percentages conventional clay and percentages finer clay, the better fields tending to have a lower moisture equivalent percentage than the mediocre fields.

The above should not be regarded as final, since the area from which this survey was made is only a part of St. Mary. However the results are given as a progress report on the survey.

C. Micronutrient Trial

An experiment which was initiated by the Crop Physiologist towards the end of 1958 is now under the direction of the Soil Chemist. Preliminary observations have been made on the effects of applying various minor elements to bananas. The minor elements applied to the soil were magnesium as Kieserite, manganese, iron and zinc all as chelates; Esminel (a proprietary mixture of minor elements), boron as borax and molybdenum as sodium molybdate were applied as foliar sprays. The experiment is still in progress.

D. Effect of Drying Temperature on Soil Analysis Values

The standard procedure in preparing soil samples for analysis is for them to be air-dried before being beaten and sieved. As airdrying is slow it was decided to dry samples at 40°C., so an experiment was set up to compare the analysis of air dried samples with those of samples oven dried at 60°C. and 40°C. The effect of drying at the higher temperatures as compared with air drying was unknown for Jamaican soils.

Bulk samples of two different soils were taken at depths of 0"–9" and 9"–18", the two soils being Agualta Sandy Loam and Water Valley Silty Clay. Each sample was thoroughly mixed and subdivided for the different treatments. The airdrying took about 3 days while the oven drying lasted about 24 hours. After this the samples were beaten in an iron mortar, screened to pass a 2mm sieve and then stored in aluminum tins for a few days. Routine mechanical analysis, pH, available phosphate and available potash determinations were carried out on each sample in replicates of eight.

The statistical analyses carried out on the results showed no particular consistent trend, except in the case of the available potash which was 1.3 to 1.9 times higher in samples dried at 60°C. than samples dried at 40°C. or air dried. (Appendix Chem. 2 A & B).

A comparison of the figures for the percentage moisture and available potash of the soil samples showed that the smaller the percentage of moisture in the soil sample the higher the available potash. This is much in agreement with the work of Luebs (1957) who, in a study of some Iowa soils, showed that drying a soil produced an increase in exchangeable potash which was particularly sharp below a 10 per cent moisture content.

All potash determinations in soil samples therefore should be carefully standardised with regard to methods of drying. In future the temperature used for this purpose in the

Research Department is to be 40°C. Further investigations are to be carried out on length of drying at this temperature and its effect on the available potash as related to percentage moisture in the soil.

E. Vacation and Scientific Tour

On the 8th of July, 1959, the Soil Chemist left on 3 months' vacation which included a scientific tour of Great Britain and Europe. During that period visits were made to several Research Stations including Rothamsted Experimental Station, The Macaulay Institute for Soil Research in Great Britain, and the Buntehof Agricultural Research Institute in Hanover, Germany.

IV. REPORT OF ANALYST (DOROTHY E. BOLAND)

The use of Banana Leaf Analysis as a means of diagnosing deficiencies of major elements has been the prime topic of work in this section. During the year, work on the development of a suitable standard technique for leaf analysis was continued. From previous investigations, a plant in an active vegetative growing stage was chosen for sampling and collection of samples was extended to three sites of varying productivity. Leaf samples were also taken from 'premature yellowing' experimental plots and from N, P, K fertilizer trial plots. Samples of fertilizer mixtures and other miscellaneous samples e.g. coir dust, humus, were analyzed. An attempt was made to keep the 'plant' analytical section running smoothly despite drawbacks from changes in personnel, major difficulties with laboratory instruments and disturbances from building operations adjacent to the department.

A. Leaf Analysis

Monthly collections of leaf samples were continued for the primary project on hand, that of using leaf tissue as an index of the nutritional status of the banana plant. The first five fully opened leaves were taken from four plants on each site. Samples from areas of good and poor production were analyzed to see whether poor plots gave consistently poor results and vice versa. Soil and leaf samples were taken from the three sites; two of good production (good areas A and B) but different soil type and one of poor production adjacent to a good area A. The good area A was the site of a fertilizer experiment and the poor area was the control plot to which no fertilizer was applied. The plants there showed visible signs of nitrogen deficiency. The good area B was assumed to be of uniform fertility and supported vigorous high-yielding plants. Correlation of leaf and soil analytical results has been attempted.

Average values of N,P,K from leaves 2 and 3 throughout 1959 are presented here (Appendix Anal. 1). Results for the poor area were divided into eastern and western sections as there appeared to be some difference between them.

Leaf nitrogen was highest in the good area B, slightly lower in good area A and very low in the poor area. Phosphate was higher in the poor area than in the good areas and potash values for the poor area were on par with those in the good areas.

Soil analysis revealed low phosphate in the poor area and the good area A, moderate to high potash in all areas, with the highest values in the poor area. It could safely be assumed that the poor area differed from the others mainly in respect of nitrogen since no fertilizer was applied. Analysis figures are given in Appendix Anal. 2.

Nitrogen and potash status in the soil were reflected in the leaf analyses but there was high leaf phosphate where soil nitrogen was low. Potash absorption appears to be independent of the nitrogen status of the soil since there was no appreciable difference between good and poor areas.

An attempt has been made to draw inferences from the available results regarding the selection of a leaf to be analyzed and ideal time for sampling.

(i) **Selection of a leaf:** The growth habit of the banana plant makes it very simple to identify leaves selected for sampling and hence to determine the response shown by different leaves to existing soil conditions. From work done in 1958 on the first five fully opened leaves from plants at different stages of growth, the choice of leaf (mainly controlled by the form of the nitrogen curve) appeared to be between the second and third leaves (Boland, 1958) for stage 2 plants. The stage 2 plant is equivalent to an age of 6-8 months.

Wide variations in nutrient content were obtained on analysis of leaves 2 and 3 from plants of similar age growing on uniform areas. Some consideration was therefore given

to assessing the age of the leaves. To do this an arbitrary system of defining the stage of development of the heart leaf was adopted (Tai, unpublished 1956). Ten arbitrary stages between the commencement of emergence of the heart leaf and full expansion of the lamina are named and the stages are recorded as decimal fractions of the fully expanded leaves. This system was first used to measure the rate of production of new leaves.

Leaves between 16-25 days old were sampled from N,P,K experimental plots and in most cases these were either leaves 1 or 2.

Values for N,P,K from sites of good and poor production when plotted against leaf age (days) gave a recurrent pattern covering a ten or thirteen day period. Since these periods fall within the times stated for unfurling of the heart leaf, one can postulate that the stage of development of the heart leaf exerts a profound effect on the nutrient content of the fully expanded leaves and should therefore be taken into account when choosing a leaf for sampling.

Some workers (Brun, 1959) have noted physiological differences between the right and left sides of the leaf. An age difference exists between both sides of the lamina, which is apparent when the unfurling process of the leaf is observed. For purposes of standardisation the right side of the leaf (viewing the upper leaf surface from the petiole) has been chosen for sampling. The middle portion of the leaf (2 ft. in length) may be taken instead of one complete side of the lamina and is recommended when composite samples are being taken, but greater care must be exercised with this method of collection.

(ii) **Time of Sampling:** Areas under routine investigation were sampled at monthly intervals but occasionally the Department is requested to sample an area showing abnormal symptoms. It is helpful to have some idea of the monthly variation of nutrients as affected by increased growth rates and by rainfall so that some allowance can be made in areas where only one sampling is possible. Some prominent workers in the field of leaf analysis of crop plants have stated (a) that comparison of the chemical composition of samples should only be made when samples are collected at similar periods during the year (Broeshart, 1956, 7) that the proper part of the plant be sampled at regular intervals during the growing season (Ulrich, 1943) and (c) that the middle of the growing season, when leaf changes were at a minimum, afforded the most stable period for sampling and leaves taken at this time showed greatest sensitivity to changes in nutrient supply (Emmert, 1959).

The monthly variation in nutrient content of the leaves was investigated throughout 1959 and an attempt was made at correlating the changes with rainfall and the existence of a period of increased growth. Rainfall and total dry matter figures were obtained for the areas under investigation. Average N,P,K values for leaves 1 to 3 were plotted against months of the year and related to the rainfall of the month immediately preceding collection of the sample in each instance. (Appendix Anal. Diag. 1).

(iii) **Rainfall and growth:** Rainfall in Jamaica tends to be concentrated into two seasons — April to July and September to November. The possibility of rainfall affecting the composition of leaf samples is one which cannot be ignored since rainfall is intimately connected with growth especially on the non-irrigated banana growing areas.

Nitrogen rose after each rainy period and remained on a much higher plane towards the end of the year. A possible explanation is the accumulation of appreciable amounts of nitrate in the top soil during dry periods. These reserves become available to the plant when the rains begin and support a sudden flush of development. This effect was observed on the poor area which received no fertilizer while under investigation. When sampling was started in September 1958, the plants were stunted in growth and had pale yellow-green leaves. The nitrogen contents were between 1.4 and 2.0%. By July and August 1959, after the heavy rains in June, the leaves of these plants were all green and although the plants were still stunted, they appeared to be quite healthy. The nitrogen contents had increased to between 1.8 and 2.7%, with the majority of results greater than 2.0%

Phosphate and potash showed a tendency to follow the rainfall pattern. Between the months April to September there was a similar trend in each area. Values rose from April or May reaching a peak in June or July, then there was a "falling off" reaching the lowest points in September. Potash values also varied between December and April tending to rise in January and to fall off towards April and May. This may be interpreted in connection with the slow growth rate known to occur in the first quarter of the year.

More intense investigation into this aspect of leaf analysis is necessary. It is proposed that several areas where the chemical composition of the soil is known and where routine application of fertilizer is done, be analyzed from April to September and the response to nutrient supply used to indicate the ideal time to sample. Special emphasis should be

placed on the growth stage of the plant, the stage of development of the heart leaf and the leaf chosen for sampling.

As a routine measure, samples were collected before wilting occurred since it was not known how the major nutrients varied throughout the day. The diurnal variation of these nutrients is now under investigation.

B. Fertilizer Analysis

Analysis of fertilizer mixtures and Humber Fish manure were done for the A.I.B.G.A.

Analyses were also done on coir dust, and filter press mud, which are used in some areas for mulching banana fields.

Nitrogen, phosphate (water-soluble and citric soluble), potash and moisture determinations were done on the air-dried samples. (Appendix Anal. 1).

V. REPORT OF AGRONOMIST (V. R. LUMSDEN)

A. Cultivation Experiment

(i) **Pruning:** Five experiments initiated by the Crop Physiologist were handed over for continuation. In these experiments various pruning schedules are being tested with a view to producing the bulk of the crop in the summer months.

Together with these there are nine plots in different parts of the island which are being pruned according to the plan described by the Research Department Occasional Bulletin No. 1. These plots are now producing their first ratoon crop and the results have been far from satisfactory.

One of these sites, in the hills of Westmoreland, after a good start was badly ravaged by leaf spot disease and drought and another site in St. Thomas was abandoned when the owner decided that the returns did not justify the cultivation expenses. A preliminary examination of the records show that with the exception of one site in Portland, the plant crop shooting was spread out over several months and this in turn caused an even greater spread of the first ratoon shooting. At the same time there does not appear to be a great deal of difference between the time of shooting in the controlled pruning area and that of the standard estate practice. The reason for this appears to be the unpredictable pattern of sucker production. Because of this, clean pruning, as called for by Occasional Bulletin No. 1, might lead to no further suckers being produced until much later in the plant's life. In order to counteract this, if there is no desirable sized sucker in the mat at the time of selection, another sucker is left as an insurance. This practice of leaving an "insurance" sucker ensures that there is a reasonable succession of plants even if the timing is somewhat upset.

(ii) **Weeding and forking:** One experiment has been laid down in Portland to determine the effect of selective weeding, in particular water grass **(Commelina spp.)**, on the fruiting records of Lacatan. The treatments consist of clean weeding, circle weeding and no weeding. A further treatment of forking versus no forking is superimposed on the above treatments.

B. Sucker Timing Observations

An interim report on these plots was given in the 1957-1958 Annual Report. Plots were established at various altitudes throughout the island in an attempt to determine the time taken by a ratoon "peeper" to produce fruit at the different altitudes.

Ten suckers at the peeper stage were marked in a large number of plots at various altitudes throughout the island in each of the following months, May, August and December 1956 and March 1957, and records were taken of their growth until shooting.

The severe and prolonged drought of 1957 severely affected the plants in some plots, particularly in St. Mary and some in St. Ann and these badly affected plots were omitted from the analyses.

Owing to the fact that suckers were marked at such an early stage, losses, from suckers dying back, or being affected by cuts from weeders, or blow-downs, were sustained in some plots. In other instances plants failing to develop normally by virtue of early damage, borers or position in the mat were omitted from the analyses. Thus all the calculations were based on 60% of the plants in the plot.

The correlation coefficients between months to shooting and altitude were worked out and these were found to be significant in all cases. Thus as altitude increased so did the time taken to shooting. The regression coefficient of the time taken to shoot on the altitude

was then correlated and then tested by calculating the "t" on the regression coefficient. In all the cases the regression coefficients were highly significant ($P < .001$).

The average time taken to shooting for all the May marked plots was 18.3 months whereas for the August, December and March plots the average was 20.3, 20.7 and 20.0 months respectively. (Appendix Agr. 1). This is probably due to the fact that the suckers marked in May were slightly older than those marked in the other months. Although the average height difference between the May marked suckers and the August and December marked suckers was only 4", Leach (1958b) has shown that for "peepers" under 12" in height this difference probably represented 2 months' growth at that time of the year.

From these results it appears that for every 500 feet increase in altitude above sea level there is an increase of approximately 2 months in the time taken for ratoon bananas to shoot. There was great variation in the overall time taken to shoot particularly at the lowest altitudes but there were inherent differences in the sites with regards to soil type and fertility, and rainfall.

One of the things noticed at the time of marking suckers was the scarcity of recently emerged "peepers" in the plots during December and March. This supports the view that periodicity in the production of suckers has upset attempts to prune in order to regulate monthly production.

C. Fertilizer Experiments

(i) **NPK trials:** At the beginning of 1959 there were six 3^3 factorial experiments in progress. Two of these were in St. Mary, two in St. James, one in St. Ann and one in St. Thomas. All six experiments were still in progress at the end of the year.

(ii) **Urea experiment:** Two experiments were laid down with a view to finding out an economic level of fertilizing Lacatan bananas in a high population stand using urea as the fertilizer. Each experiment consists of 5 treatments in a randomised block layout with 5 replications.

(iii) **Fertilizer + Nemagon:** It has been suggested that the results of the fertilizer experiments are being influenced by nematode infestation of the banana roots within the plots. In co-operation with Shell (Chemical) Co., two experiments were laid down in which similar fertilizer treatments were applied to plots treated with and without Nemagon.

VI. REPORT OF NEMATOLOGIST (C. A. LOOS)

The Nematologist assumed duties on September 1st, 1959. The period, under review, was worked under rather adverse laboratory facilities as the builders failed to complete their programme until late December. However, this delay enabled more time to be spent on field surveys and the laying down of field experiments.

A cursory island-wide survey of banana plantations, to ascertain the distribution of plant-parasitic nematodes and to correlate, where possible, a relationship between a particular species and disease symptoms on the plant, became necessary before any planned experimental programme was possible. Conduct of this preliminary survey was facilitated through the Plant Pathologist's knowledge of diseased areas and previous work in Central America on nematodes associated with bananas.

Survey results indicated that the burrowing nematode, **Radopholus similis** (Cobb, 1893) Thorne, 1949 was widely distributed throughout banana areas and was a major factor in a root-rot complex of Lacatan and Robusta varieties. Root-knot nematode, **Meloidogyne incognita acrita** Chitwood, 1949, which induces swellings or galls on roots, was also very common but attacks did not appear to be severe or intensive. These two nematode species are endo-parasitic forms. The association with disease symptoms in the banana plant are described later in this report.

A number of ecto-parasitic nematodes were also encountered. These forms may breed to gigantic numbers without causing appreciable damage to the host plant.

With the completion of this preliminary survey it was possible to plan a future research programme under the following broad groupings:–

(a) Survey of nematodes associated with banana cultivation; the distribution of plant-parasitic nematodes in virgin lands and on other cultivated crops grown on banana land.
(b) Effect of rotational crops on the incidence of the burrowing nematode.
(c) Control of major nematode pests.
(d) Establishment of nematode-free banana plantations.

A. **Survey of Nematodes Associated with Banana Cultivation.**

234 soil samples were processed in the laboratory and examined for plant parasitic nematodes, in addition to hundreds of root and rhizome examinations in the field.

(i) **Burrowing nematode:** The earliest record of this pest was in 1893 when Cobb found males in soil around diseased banana roots in Fiji. Later Cobb (1915) described both sexes as **Tylenchus similis** (now a synonym of **Radopholus similis)** from banana rhizomes sent to him by Ashby from Jamaica, W.I. Since then the pest has been recorded from most tropical and sub-tropical countries.

Major diseases caused by **R. similis** infections are better known as "spreading decline of citrus" in Florida, U.S.A. and "yellows disease of pepper" in Banka, Indonesia. The descriptive common name "black-head disease of bananas" suggested by Ashby in 1915 was lost in oblivion until Leach (1958c) suggested its re-adoption, with an addition, as "black-head toppling disease of bananas". Although "toppling" is one of the more serious symptoms of this disease its occurrence is not sufficiently common to warrant adoption of this symptom into the descriptive name of the disease. Loos (1960) has restored Ashby's common name.

There is still some considerable difficulty amongst growers in distinguishing between black-head disease and borer damage. A short description of black-head disease symptoms is desirable to help in its identification. On rhizomes the infection causes blackening of the skin or epidermal tissues above the infected lesion. In large rhizomes this blackening may extend 4 inches in width while in small material, such as sword suckers, the entire rhizome may be involved. Although epidermal blackening is found in Gros Michel, Robusta and the Dwarf Cavendish varieties this symptom is more conspicuous in the Lacatan banana. Lesions, or infested areas, are clearly visible on lightly paring the outer skin of the rhizome. The centre of the lesion is black but the edges have a characteristic pink-red colouration. Lesions always surround embedded roots which in a banana rhizome originate from the central fibrous section and pass through the thickness of the white fleshy food-storing tissues before being externally borne. The central black tissues in the lesion and often the embedded root disintegrate with age, forming cavities suggestive of borer galleries. Under adverse weather conditions lesions may become water soaked and tissues prematurely invaded by rot causing organisms. When this occurs the nematodes evacuate the lesion and the pink-red border disappears. In such cases, too, there may be confusion in determining whether the rotted cavity was formed by burrowing nematodes or by borers.

Although rhizome infections may be large and deep seated they have very little influence on the assimilation of plant nutrients, though the plant's food storage capacity is reduced. These infections are, however, very important as a means of distributing the pest to new or replanted areas when diseased rhizomes are utilized as planting material.

Brown to black lesions, with slightly sunken centres and longitudinal cracks, up to four inches long and girdling the root are common on the root system of heavily infested plants. Characteristic internal symptoms of these lesions are best observed in infections over one inch long if the root is split centrally and longitudinally through the lesioned area. The advancing edge or perimeter of the lesion, as in the rhizome lesions, is pink-red or wine colour with the aging centre brown to black. A streak of reddened tissues may extend one-half inch beyond the lesion, in close contact with and parallel to the stele. The fibrous central cylinder is not invaded by the burrowing nematode though later the thick fleshy cortical tissues, which surrounds it, breaks down and permits invasion by other rot inducing organisms. The root beyond the infected point is then destroyed.

Since the focus of infection is generally a 'seed' rhizome, and all roots originate from deep inside the rhizome, the nematode does not have far to wander in search of a host root. This is the primary reason why the majority of root infections are confined to the vicinity of the plant bole and the probable reason why there is little difference in disease incidence between plants grown in sandy and clayey soils.

The tendency for root infections to be mainly in the vicinity of the plant bole results in a large number of shortened roots, 3 inches to 2 feet long, on heavily infested plants. These short roots are inadequate anchorage to the plant which may tip over under wind-pressure or from leverage exerted by weight of developing fruit. On plants that topple over anchorage roots generally break at a lesion, which is the weakest point.

Depth of the plant bole in soil has a bearing on proneness to topple; plants with deep-seated boles stand up more satisfactorily than shallow-set ones.

(ii) **Root-knot nematode: Meloidogyne incognita acrita** is the commonest of root knot nematode species found throughout South-East United States and Central America. This

species was found widely distributed through banana plantations. It causes galls or swellings on young rootlets though on thick fleshy primary roots, a single mature female may be found embedded in the tissues without causing root swellings. Knots or galls contain many females, the number depending on the size of galled tissue. These females appear as small pearl-like bodies when a clean cut is made through a gall. Solitary females apparently enter into well-developed primary or secondary roots through young rootlets, develop normally but are unable to stimulate proliferation of older tissues. The plant forms a sac-like membrane around such females while egg masses remain undeveloped or only partially so. Tissues immediately surrounding an embedded female become brown to black making a rounded lesion about 2 mm. in diameter deep in thick, fleshy cortical tissues of larger banana roots. Egg masses dissected from these apparently dormant females, when placed in a drop of water, develop normally. A similar phenomenon may occur in potato tubers (Christie, 1959). No root knot infections were observed in banana rhizomes though roots may be affected in close proximity to it.

(iii) **Ectoparasitic nematodes:** Many ecto-parasites were found in association with banana roots. **Hoplolaimus** spp., **Tylenchorhynchus** spp., **Helicotylenchus erythrinae, H. multicinctus** are found in very frequent association with the plant. While their normal habitat is as an ectoparasite they may, on occasion, be found living endoparasitically in plant tissues, especially in shallow lesions in the rhizome. Severe attacks may cause destruction of small roots. **Criconema** sp, **Xiphinema americanum, Hemicycliophora typica, Paratylenchus** sp, **Trichodorus** sp. and **Hoplolaimus coronatus** are found occasionally in samples. The ectoparasites form minute purple superficial lesions, often only a few cells deep, on the larger roots. This clearly differentiates them from lesions formed by the burrowing nematode deep in the fleshy cortical tissues almost in contact with the central fibrous cylinder of the roots.

(iv) **Soil sampling:** Banana fields support a number of weeds and grasses besides coconuts, cocoa and numerous fruit trees where mixed cultivation is practised. Soil samples alone, except where cultivations not in banana are being sampled for the presence of the burrowing nematode, therefore serve little purpose unless the roots of the vegetation are also examined. The root-knot nematode and many of the ecto-parasites previously listed have a long host range and though they may feed on bananas their more attractive host may well be some other plant. Soil surveys are laborious and time consuming if all the soil fauna have to be recorded. Under such conditions a single sample may take hours or days to complete and an army of trained workers becomes necessary to make an island wide survey. In examining land which has been out of bananas the presence or absence of the burrowing nematode is the main purpose as that pest is of primary importance. A brief summary of the presence of other pests is recorded but no special importance is laid to this observance unless a form, known to cause severe damage in another crop, is found.

(v) **Survey of virgin lands and land out of banana cultivation for many years:** Very little virgin forest is available in Jamaica for expansion purposes but some considerable land exists which has been out of bananas for many years.

(a) St. Catherine. A block contained a large number of Guango trees **(Samanea saman)**, numerous grasses and other unidentified weeds. No burrowing nematodes were observed in any of the numerous samplings of soil and roots of those plants. The ectoparasite, **Helicotylenchus erythrinae,** was frequently encountered.

(b) Sherwood Forest, Portland. An area of approximately two thirds of an acre which had been out of bananas for at least 5 years, except for one mat of Lacatan plants about two years old, and heavily infested with the burrowing nematode, was examined. The following plants were free of the burrowing nematode:– Guava **(Psidium guajava),** Indian Almond **(Terminalia catappa),** Breadfruit (**Artocarpus incisa), Citrus** spp., Soursop **(Annona muricata),** Dandelion **(Cassia** sp.), Wild Ginger **(Zingiber** sp.), Wild Tomato **(Solanum** sp.), **Mimosa** sp., coconut **(Cocos nucifera), Stachytarpheta** sp., wild cosmos, ferns, grasses and many other unidentified weeds.

Pratylenchus coffeae (a lesion nematode) was found on breadfruit roots; **Pratylenchus** sp, on Indian almond; **Rotylenchulus** sp. probably identical with **R. reniformis,** the reniform nematode, was in association with the dandelion weed; root knot (**Meloidogyne** sp.) was found on wild ginger and wild tomato.

(c) St. Catherine. About 5 acres in grass and large trees, with no previous history of banana cultivation, was examined. An extensive sampling of roots and soil around roots of grasses, weeds, etc., failed to give rise to a single specimen of burrowing nematode.

(d) St. James. The field had been in sugar cane since 1952, following bananas, and then in pasture over the last 2-3 years. No burrowing nematode was found in any of the soil and plant root examinations.

(e) St. James. A 5 year old citrus planting contained many citrus varieties. Root samples from 9 of 10 plants examined were free of the burrowing nematode. One Ortanique plant gave rise to a few specimens of **Radopholus.** There was the possibility of contamination from roots of an infested banana growing in close proximity to the citrus plant. **Rotylenchulus reniformis,** the reniform nematode, was found in all samplings.

(f) Trelawny. An area of about 3 acres, in bananas many years ago, had been replaced by sugar cane and then abandoned to pasture and bush. About half of one acre was chopped of vegetation and the whole area deep forked when soil samples were taken. The samples were free of the burrowing nematode. The vegetation at time of planting was chiefly tall grasses and weeds.

(g) St. Mary. Two areas near Port Maria which had been out of bananas for a considerable time and a block of virgin land in Highgate were sampled and found to be free of the burrowing nematode.

All these examinations, which were made over a representative cross section of the banana areas, support the previous reports from Central America that the burrowing nematode is not indigenous to this section of the world. They also indicate that sugar cane, most other vegetation associated with fruit crops, and abandoned areas are unattractive to the burrowing nematode.

B. Effect of Rotational Crops on the Incidence of the Burrowing Nematode

One of the most effective means of controlling nematode-pests lies in the rotation of susceptible and resistant crops provided that the rotation makes an economic return.

(i) **Sugar cane rotational planting:** Numerous examinations of cane roots in different sections of the island failed to show the presence of the burrowing nematode, though the root knot and another lesion nematode, **Pratylenchus zeae,** were very common. **P. zeae** was often encountered, though in very small numbers in soil around banana roots though not in the root itself. The infection was probably in one or other of the many weeds and grasses found growing in association with bananas. Areas planted from bananas to cane quickly build up a large population of lesion nematodes, **P. zeae,** while large populations of this pest are considerably reduced when bananas replace sugar cane. Root-knot nematodes, too, find cane a most susceptible host and populations build up to gigantic numbers in a short time. There are numerous references of the susceptibility of sugar cane to the burrowing nematode and the apparent resistance of cane, in this country, is most surprising.

Examinations of sugar cane in areas which had followed banana cultivation were made in fields of different ages from such plantings. Thirty samples (15 of roots and 15 of soil from around roots) taken 4 months after planting cane, variety B42231, in land cleared of bananas which were heavily infested with the burrowing nematode, were found to be free of this pest. Passenger banana plants, growing from imperfectly destroyed rhizomes in open spaces and along drain edges, showed burrowing nematode infestation indicating the generally high level of infection in the field at time cane was planted. Root knot nematodes were most prevalent while the lesion nematode, **P. zeae,** though in small numbers, was general through the area.

Five plots each approximately 50 ft. square were cleared of cane and planted with 16 pared nematode-freed banana rhizomes, at spacings of 8' x 8', at the end of October. These plants will be removed and examined after about seven months, when surrounding cane is harvested, for evidence of burrowing nematode infection. The seven month interval is considered sufficiently long for any possible burrowing nematode residue left behind by the cane and overlooked in original root and soil examinations, to build up on susceptible bananas to show evidence of infections.

Cane variety B 4362, 13 months after planting in a banana area which was heavily infested with burrowing nematode at planting time, had 25 root samples taken at random through the field. Samples failed to reveal a single specimen of burrowing nematode while root-knot and **P. zeae** were found in large numbers. The cane was over 12 feet tall at the time of sampling.

Eight plots, 50 ft. x 50 ft., were set up in a 14 month old B 41227 variety cane field which had a preplanting history of bananas severely infested with burrowing nematode. Five soil samplings taken from each of the eight plots, 3 weeks after the cane was cleared, and processed for nematode examination were free of burrowing nematode while 37 of the

samplings had large numbers of lesion nematode, **P. zeae.** Root-knot nematodes were in 21 of the 40 samples. While the burrowing nematode had disappeared the lesion nematode was assuming proportions which must eventually affect cane production.

Five plots were planted with pared and 3 with regular, unpared banana rhizomes in a randomized plot distribution. About July 1960, when the surrounding cane is harvested and the bananas are about 8 months old the plants will be removed and examined for burrowing nematode infestation as well as possible parasitism with **P. zeae.**

A further experiment to ascertain the immunity of sugar cane to the burrowing nematone was set up in the St. Thomas area. The area selected had not been in bananas for at least 10 years and was, at the time of selection, in sugar cane variety B 37122. The cane was cut down on November 4th, 1959. No attempt was made to fork up the area but it was lined and holed for planting with bananas 9' x 9' apart. On November 5th, 294 pared rhizomes were planted after it was ascertained that the plot was **Radopholus** free on soil sampling. Very heavy rains in December caused the planting holes to fill with water and only 40 per cent of the rhizomes sprouted. The plot was forked and drained for resupplying with 'seed' which was pared early in January 1960. A few weeks later floods, for the second time, completely inundated the area, the flood waters passing over nematode infested banana land before inundating the experimental plot. This may cause contamination of the area and a possible infection of the banana plants. A general infection of the experimental area through contamination of the flood waters, may have resulted. This will be ascertained when the plants are examined in June, 1960.

(ii) **Abandoned areas:** Rhizomes of bananas are severely damaged when abandoned plantations are planted up though a few suckers continue to grow. Repeated discing or frequent rounds of digging up the sprouters are necessary before the field is completely cleared of banana plants.

In September, 1959, a 3 acre block of burrowing nematode infested land was ploughed and harrowed in May after having been in sugar cane from 1947 to 1952, and in bananas from 1952–May, 1959. Between May, 1959, and the end of September 1959 all growth was knifed back on two occasions and harrowed again early in September. At that final harrowing a few small banana plants, infested with the burrowing nematode still persisted. This meant that although the plot had been abandoned for 4 months infection points were still present on persisting banana growth.

The block was divided into 3 approximately equal sections, each section in turn being divided into 2 plots. A dividing drain was cut between each plot. Section 1 plot A planted with 300 pared Lacatan rhizomes at spacings of 9' x 9' on October 7th, 1959. On December 17th, it was necessary to re-supply 18 vacancies i.e. successful germination of pared seed was 94 per cent. At the same time Section 1 plot B was given an application of Nemagon (at rate equivalent to 5 gals. active ingredient of emulsifiable concentrate per acre). This plot was planted 2 weeks later with pared Lacatan rhizomes. Germination was 88 per cent. The vacancies were re-supplied on December 17th, 1959.

Section 2 will be planted about the end of January, 1960 (8 months abandonments).

Section 1 will be examined for nematode infections when the plants are about 7 months old.

C. Control of Major Nematode Pests

While it is premature to discuss control measures of major nematode pests of bananas a brief discussion of principles of control may be desirable at the present time. The two main control forms are agricultural and chemical.

The agricultural control method of crop rotation is the most widely used nematode control method. An example of this is with the Golden Nematode of Potatoes in England and Europe. In England fields heavily infested with golden nematode can grow only one crop of potatoes in 4-6 years. Non-host crops must be grown during the intervening years. Unfortunately there are limitations to the use of rotational crops if more than one nematode pest is involved as host susceptibility varies between nematode species.

Chemical control, on the other hand, gives quick pest reduction while it is less likely to be specific in action between species. However, decomposition of living plant tissues (rhizomes and roots of bananas) is most important if chemical control of nematodes which live within the plant tissue, is required. The burrowing nematode and root-knot are two examples. Repeated discing and breaking up of large roots and rhizomes of banana plants are needed to cause decomposition and to free the nematodes from the tissues into soil

where fumigation will be effective. In the application of nematocides to standing perennial crops, such as bananas, the timing of such applications is important in order to protect new root growth from infection, since once infection occurs the nematode colony builds up in the root well protected from the effects of the fumigant.

Agricultural in preference to chemical control methods were pursued as experiments with fumigants had already been initiated by the Department. Duplication was considered unnecessary until more was known of the results of that work.

D. Establishment of Nematode-Free Banana Plantations

Clean "seed" grown in clean soil must give rise to nematode-free plants. To prove that the establishment of burrowing nematode free plantations was possible demonstration plots with pared or nematode free 'seed' were established in different parts of the island.

(i) **Nematode-free 'seed' preparation:** While all rhizomes of varying ages and sizes in a banana mat may be used as 'seed' for propagation purposes the general farm practice is to utilize the larger rhizomes either as "bullheads" or large maiden heads. Paring for the preparation of a clean 'seed' entails the removal of all large buds around the periphery of the pseudostem base and one or two of the outer rings of those leaf attachments, making the 'bull head' unsuitable for nematode-free 'seed' preparation. The large 'maiden heads' are more desirable since the base of the pseudostem carries a number of leaf attachments and, although an outer ring with the larger axillary buds may be removed at paring, what remains is sufficiently large and active for healthy growth. However, if the rhizome heart bud is left intact or incompletely removed growth originates at that point and the axillary buds lie dormant or make weak growth responses. The rhizome is further trimmed by removing a large slice from the basal end leaving only a couple of inches of the rhizome. This basal end is superfluous as roots originate from immediately below the pseudo-stem attachments and seldom from the rhizome base. A pared 'seed' is then dipped for one to three minutes in a Bordeaux-Nemagon mixture (22 pounds lime, 22 pounds copper sulphate, 3 ozs. Triton 100 and 25 gallons water to which sufficient Nemagon emulsifiable concentrate is added to make a concentration of 1 in 500 of the active ingredient). After dipping the 'seeds' are placed in a single layer and allowed to dry, under cover, for at least 24 hours before being planted. A shellac-like exudate gradually seeps out from the pared tissues and sets hard, in 2-3 hours, as a thin film around the rhizome. There is no indication that this exudate affords protection from rot causing organisms.

Demonstration plots carrying a total of 4,133 clean 'seed' were set up in twelve different localities throughout the island.

The extent of paring is dependent on the intensity of nematode infection, borer damage and the care in which the rhizomes are removed and transported. Deep machete or cutlass cuts require extensive slicing, to remove the gashes. Heaping rhizomes together bruises the pseudostems which then rots quickly and requires deeper paring to make a clean 'seed'. Under ideal conditions sprouting should be in the region of 94-99 per cent. Water logging conditions reduces sprouting of pared 'seed' considerably. In one planting success was at 94%, on another with a mixed supply of 'seed' it was 83% while in an area where water stood in the planting holes for some days success went down to only 40%.

Acknowledgments. Grateful thanks are extended to Mrs. C. A. Loos for her invaluable help in preparing nematode-free seed.

VII. REPORT OF PLANT PATHOLOGIST (R. LEACH)

A. Leaf Spot Control

(i) **Oil spraying:** In the Annual Report, 1957/8, attention was drawn to the increasing antipathy of growers to the use of spray oil due to phytotoxicity, the manifestations of which were, notably, discoloration of foliage, scorching of the fruit and sheath-splitting. At the same time several oils had been screened by the Oil Companies and tested for control of leaf spot by the Research Department, with special reference to their phytotoxicity. As a result a new oil was used for spraying bananas throughout Jamaica by the All Island Banana Growers Association at the beginning of 1959. Complaints from growers have been conspicuous by their absence since then. As Bordeaux spraying has greatly deteriorated, due largely to the inability of labour to maintain the required standards of application, the success of the new spray oil has been opportune.

By the end of 1959 the A.I.B.G.A. had introduced mobile units, spraying under contract to the smaller growers and trials had been carried out by the Research Department

proving that leaf spot, on bananas growing under tall coconut palms, could be controlled by high level aerial spraying. Fixed wing aircraft replaced helicopters on the irrigated plains owing to the reduction in cost of application.

(a) **High level aerial oil spraying:** When the Director of Research was on overseas leave in 1958, the Banana Board was approached by Messrs. Crop Culture (Aerial) Ltd. with a claim that leaf spot could be controlled on bananas growing below tall trees such as coconut palms by the application of oil from fixed-wing aircraft using Micronair, centrifugal atomisers. Trials with this method of spraying were started under the supervision of the Research Department in February 1959.

Four twenty-five acre plots were chosen, three in notoriously bad leaf spot districts, namely, Portland (A & B) and Bog Walk (C) while the fourth was in the centre of the important St. Mary banana area (D). The leaf spot was under good control on all four estates, except for a small patch of badly diseased bananas in Plot B. Plots B & C had been under regular oil spraying for over two years while Plots A & D had been efficiently sprayed with Bordeaux mixture. The bananas were growing under 60 ft. high coconuts in all plots except B where the coconuts were only a little higher than the bananas but one side of the plot was bordered by trees near the badly diseased patch. All spraying was of necessity carried out in the early morning when wind is practically absent. The spray cycles were 2-weekly for the first five months after which they were lengthened to 3 weeks and a further 25 acres was sprayed on a 2-week cycle on the same estates. The amount of oil used was 1 gallon per acre/cycle.

Unfortunately the trials had to be started at a time of year when climatic conditions are unfavourable for infection due to low night temperatures which result in an annual decline of leaf spot in March/April even on unsprayed bananas. In 1959 this effect was continued longer than usual due to abnormally dry weather where the plots were situated. Difficulty was therefore experienced in assessing the full potentialities of this spray method for a much longer period than had originally been planned for the trial. Then again control broke down temporarily in the diseased patch in plot B which necessitated a further prolongation, so that the trials were not terminated until November.

The trials demonstrated clearly (Appendix Path. 1) that leaf spot can be controlled by oil applied from aircraft flying high above bananas growing under coconut palms, when the oil simply drifts down mostly onto the upper surface of the banana leaves. This was admittedly unexpected on Lacatan bananas because experience with helicopter spraying had shown that control tended to be poorest where the flying was done over tall trees and power cables.

At the end of 1959 another successful fixed-wing aerial oil-spraying trial was carried out by Messrs. Aviation Services Ltd., using a plane fitted with a boom for applying the oil.

Note. In 1960 high level oil spraying by fixed wing aircraft is proving very effective commercially as a means of controlling leaf spot on Lacatan and Robusta bananas both in the open and under the shade of coconut palms and other trees. This type of spraying is becoming increasingly popular because it is reducing leaf spot to such an extent that smaller and smaller quantities of oil are being applied per acre/cycle, thereby minimising oil phytotoxicity. In some unshaded plantations on the irrigated plains the rate of application has been reduced to only half a gallon of oil per acre/monthly cycle even when the weather has been favourable for leaf spot development for several months.

The possibility of oil adversely affecting the yield of coconuts over a period of years is being closely watched. Experience to date does not indicate that this will be the case. The absence of nut fall due to oil was mentioned in the Department's Annual Report for 1956-57.

(b) **Oil phytotoxicity:** Two blocks of a 3^3 factorial fertilizer experiment situated in a field of oil sprayed bananas were used to examine whether phytotoxicity is affected by the nutritional status of the plant. An estimate of the amount of flecking in the foliage was made on the unshot plants in each fertilizer treatment plot. The Index Number for flecking was calculated by the method described in the Annual Report 1957/8, p. 18.

The first estimation (I) was made by sampling the 5th and 6th youngest open leaves on each plant. The results, in Appendix Path. 2, showed a significantly reduced amount of flecking in leaves from the nitrogen fertilized plots but this was possibly due to these leaves being younger than those receiving no nitrogen in which case the latter might have received an additional application of oil.

Two further tests (II & III) were made to overcome this possibility, by marking the petiole of all the first, fully open, young leaves in the plots of the fertilizer experiment on one day and then examining them at a later date. The sampled leaves were then known to be almost the same age, although their position on the plant may have varied at the time of sampling. At that time they were mostly the 6th or 7th youngest leaves on each plant. In the first of these tests the leaves from the low nitrogen plots gave a significantly higher Index number for flecking although in the second test the differences were there, but they were not significant (Appendix Path. 2). No significant differences were found between leaves from plots receiving different amounts of either potash or phosphate. Unfortunately the third block of the 3^3 factorial experiment was in a plantation not sprayed with oil so that no inter-actions could be calculated.

Plants suffering from premature yellowing due to potash deficiency usually show oil flecking badly. The absence of any difference in flecking due to potash applications, indicated an adequate potash uptake in these fertilizer trials.

(ii) **Aerial-Perenox spraying trial:** In view of the adverse reports of losses in weight of fruit from oil sprayed plantations in parts of Central America, a preliminary experiment was undertaken to test whether an aerial application of cuprous-oxide (Aerial Perenox) could maintain control of leaf spot in unshaded plantations on the irrigated plains which had been brought under very good control by the use of helicopter spraying during the past two years. Approximately twelve acres of bananas were subdivided into two plots, one sprayed by helicopter and the other by fixed wing aircraft each applying 3 lbs. of Aerial Perenox in only one gallon of water per acre, i.e., the same cost of application as with oil, though the cost of materials was greater.

The experiment started at the beginning of October 1959 and continued to the end of February 1960. The seasonal rains were late, starting at the same time as the trial and continuing longer than usual so that conditions were very favourable for leaf spot infection throughout the trial. The disease did not increase during the trial.

If there had not been a field of bananas, alongside the trial, which had been unsprayed between September and February the results of the trial might have been interpreted as indicating that the low-volume aerial Perenox application had been very effective, previous experience with Gros Michel bananas in the same area having shown that regular Bordeaux spraying could never be foregone with any degree of safety except in the cold months of January and February. When the assessment of leaf spot was finally made, in the trials and in the unsprayed field, the disease was so slight that its extent had to be judged by counting the number of individual spots on each leaf and not by the usual method of recording the estimated area of leaf killed by leaf spot.

The importance of this result is its demonstration of the difference in the aetiology of leaf spot caused by conidial and ascospore infection. **Mycosphaerella musicola** Leach used to produce waterborne conidia throughout the year and airborne ascospores only seasonally on Gros Michel in the past, whereas nowadays on Lacatan ascospores are produced almost exclusively in Jamaica. Conidia removed in dew, from a single leaf spot, are likely to settle close together wherever they fall onto a susceptible heart-leaf; on the other hand airborne ascospores dispersed from a single leaf spot are unlikely to settle close together on the susceptible, young, open leaves. The time taken for a spot to develop is determined by the proximity of individual spores causing infection (inoculum potential). Waterborne conidia can give rise to the rapid development of a number of spots in very lightly spotted plantations, whereas ascospores are extremely unlikely to do so under the same conditions. A sudden outbreak of leaf spot can therefore occur in very lightly spotted Gros Michel plantations much more readily than in similarly spotted Lacatan plantations, provided that there is no source of ascospore infection drifting from neighbouring fields.

The habit of mulching fields of young bananas with trash frequently leads to severe outbreaks of leaf spot on the very young plants because the ascospores are not widely dispersed from the trash before reaching the susceptible, young foliage. Once infection is established on young plants the leaves are so close to each other that ascospores from a few spots are able to cause much heavier infection than those from a similar number of spots on taller plants. Oil spraying should therefore commence as soon as the first leaves open in a field of young plants especially where trash has been left in a field of Lacatan or Robusta bananas. Leaf spot on these varieties is always much more difficult to stop in plant crops than in ratoon crops.

(iii) **Low volume, water-miscible fungicide spraying trials:** Two further trials were made in 1959 to test the effectiveness of mechanical, knapsack mist-spraying with copper compounds in water.

(a) Three levels of copper were applied in the form of Schering's formulated copper oxychloride and cuprous oxide (Perenox), with no unsprayed plots. There were no differences in the results obtained with the six treatments as regards leaf spot control (Appendix Path. 3). After a slow start due to drought the plants finally grew well with rainfall improving towards the time of shooting. **Cordana musae** developed severely on the oldest (10th, 11th & 12th) leaves. The effect greatly exaggerated the presence of a small number of leaf spots on the older leaves, **Cordana** killing, in its characteristic manner, a wide zone of tissue around each leaf spot with the result that the general appearance of the plantation made the grower think that leaf spot control had broken down. Both forms of copper caused scorching of the leaves where they received the direct blast from the mist-spraying machine, cuprous oxide being more toxic than copper oxychloride in this respect.

(b) Two forms of copper oxychloride were tested, one formulated (Schering) and one with Triton X-114 added as a wetting agent. There was no difference noted between the effects of the two sprays which both maintained a good standard of control throughout most of the year, but, when conditions became more favourable for the development of leaf spot disease, control deteriorated and oil spraying had to be used to restore it quickly. The same experience as this has been reported from estates which had tried this form of spraying on a commercial scale.

B. Blackhead Disease

In September a nematologist was appointed to the Research Department. Mr. C. A. Loos had begun research on blackhead disease in Central America when working with the United Fruit Company, in the same year that the disease was rediscovered in Jamaica, namely, 1957. Until his appointment, investigations on this disease were confined to trials of different chemical methods of controlling the disease which had been renamed blackhead toppling disease. With due deference and for the sake of uniformity in nomenclature the name of the disease, in these Annual Reports, will be referred to by its original name of blackhead disease, caused by the nematode **Radopholus similis** (Cobb, 1893) Thorne, 1949.

Although the nematologist only joined the staff late in the year the value of his past experience with this serious banana disease immediately became apparent and the problems of control are now capable of being based on fundamental knowledge of the organism.

(i) **Nemagon treatment of bananas at planting time:** A randomised block experiment was described in the Annual Report 1957/8 in which nemagon was applied in the planting hole, as granules mixed with Gypsum powder which were placed below the "seed" heads and as emulsifiable concentrate sprayed over the sides of the untrimmed heads. The Nemagon was applied in two different quantities with both materials, in July 1958. Although the concentrate had shown no phytotoxicity when used at a dilution of 1 in 25 with water in a previous experiment (Ann. Rept. 1957/8, pp. 21 & 39) even 1 in 50 was shown to be toxic in this experiment, possibly because the plants suffered a set back from a slight shortage of irrigation water at the start of the experiment.

In order to assess the value of the planting treatments growth records were taken regularly on every plant in the four randomised blocks, totalling 3,680 mats, planted 12 x 12 with double suckers. When the plants were nine months old it was decided to make additional use of this large plot of individually recorded plants in order to test the Vilardebo (1959) method of applying Nemagon to growing plants by soil injections round the base of the plants. The whole experiment was transformed into a multiple split plot one, with the injection treatments superimposed on the original randomised planting treatments, the smallest subplots consisting of eighteen plants.

Although the original injection treatments were applied too late to have had any anticipated effect on the plant crop, the results of the treatments applied at planting time were analysed as a split plot experiment. There were no interactions between the planting and injection treatments. Neither the Nemagon granules nor the emulsifiable concentrate treatments resulted in any improved growth of the plant crop (Appendix Path. 4). It remains to be seen whether their effect is at all apparent in the first ratoon crop.

The result was somewhat expected when an examination of the roots was made six months after planting, and there was only a slightly significant difference between the amount of damage caused by **Radopholus similis** in the treated and untreated plants (Appendix Path. 4).

(ii) **Soil fumigants:** Single sucker treatments were initiated in 1958 and continued into 1959 by applying Nemagon either as two injections, six inches away from and on opposite sides of a "crop sucker" or as a liquid poured close around it, the object being to prevent new roots being attacked by **R. similis** as they emerged from the young rhizome. Several randomized experiments were carried out on these lines. Most of the plots chosen suffered misfortune but in two experiments a methodical examination of the roots of the suckers was made six months after treatment.

The roots were cut with a sharp spade, next to the rhizome of the treated sucker and also a foot away from it on the side remote from the parent plant, the width and depth of each cut being also approximately one foot. All cut roots were then collected, wrapped in polythene and taken to the laboratory where they were duly washed prior to examination by being split lengthwise. The Index number for nematode infestation was determined by the method described in the Annual Report, 1957/8, p. 21. In one experiment the roots were cut two feet long, the infestation being examined separately on each foot length.

In general there was remarkably little difference between the amount of disease on the roots of treated and untreated suckers. In one experiment, for instance, some suckers had received as much as three applications of 20 ccs of Nemagon at two-monthly intervals. Where the roots examined were cut one and two feet from the suckers there was no difference in the amount of disease on the two portions. It was concluded that the Nemagon diffused too widely to have been effective.

(iii) **Shell (Chemical) Co. injection experiments:** When the Shell (Chemical) Company had claimed success from the use of Nemagon on banana plants, the Research Department was anxious to apply similar treatments in Jamaica. As the physical nature of the soil in the island is so variable the Department was glad to have been able to enlist the aid of the Company in experimenting with the use of Nemagon. The Department co-operated by providing facilities for laying out and taking all records of results of experiments designed and executed by the Company staff. During the year ten experiments in all were started in this way, one being designed by C. W. McBeth and nine by M. O. Lane. The results of these experiments are being recorded in the form of growth measurements, grades of fruit and in some cases weights of fruit. As the experiments were not started until the middle of the year no results are available for publication in this report.

VIII. REPORT OF ASSISTANT PLANT PATHOLOGIST (D. S. MEREDITH)

Investigations into the possibility of controlling fruit-rots, caused by **Gloeosporium musarum** Cke. & Massee were initiated. In addition, some factors influencing infection by this fungus were studied. The work described here has already been published elsewhere (Meredith, 1960 **a, b, c**) in somewhat greater detail.

A. Anthracnose

(i) **Factors affecting severity of disease:** A form of anthracnose, caused by **G. musarum,** is responsible for appreciable wastage of Jamaican 'Lacatan' bananas. Symptoms are often well in evidence on immature fruit after 8-10 days' storage in refrigerated ships' holds. On green fruit, lesions are characteristically lenticular, having a slightly sunken dark centre and an orange-yellow border: rapid increase in size occurs as final maturity is approached. The fungus readily infects small scratches on the skin and, in inoculation experiments, resulted in the development of lenticular lesions after 8-10 days' storage at 55°F. Many observations suggested that naturally occurring infections often originate at small abrasions acquired during handling of fruit.

On the basis of histological findings, it is proposed to refer to lenticular lesions as 'non-latent anthracnose', thus distinguishing this form of infection from the 'latent' type described by earlier workers.

The most important factor governing the incidence of non-latent anthracnose appears to be the care with which fruit is handled, prior to and during loading on to the ship. Only by careful handling can the numbers of scratches and abrasions, which provide points of entry for **G. musarum,** be minimized.

Experimental inoculations showed that the 'Lacatan' and 'Robusta' varieties are more susceptible to anthracnose than 'Gros Michel' fruit ($P < 0.001$). In other experiments it was found that the severity of disease increased as the 'fullness' of harvested fruit increased. Thus on light-full ¾' and 'full' bananas the mean lesion length was significantly greater than

that on 'thin' bananas ($P < 0.001$). This emphasized the importance of reaping fruit before it is 'full'. The presence of plastic bags during cold storage in the ship and during the subsequent ripening process had no significant effect in increasing the severity of anthracnose. The amount of **Gloeosporium**-rot on fruit imported into the United Kingdom undergoes marked seasonal variation being greatest during autumn and winter. Further investigation is necessary before this can be explained satisfactorily.

(ii) **Control by Nystatin:** The antifungal antibiotic Nystatin (prepared by E. R. Squibb & Sons under the proprietary name of 'Mycostatin 20') has been tested extensively under laboratory and commercial conditions.

Preliminary experiments were designed to compare the effects of dipping fruit in Nystatin at concentrations of 100, 200 and 400 p.p.m., respectively. Antibiotic suspensions were made in water, and a wetter of the secondary alcohol sulphate type was added. One hour after scratch-inoculation with **G. musarum,** fruit was immersed in the dipping medium for 5-8 seconds, enclosed in perforated plastic tubing and stored and ripened in the usual manner. Controls were dipped in water plus wetter only. The results obtained, based on the numbers of lesions which developed at inoculated points, showed that there was a significantly lower incidence of infection ($P<0.05$) on Nystatin-treated fruit (200 and 400 p.p.m.) than on water-dipped controls. There was no significant difference at the 100 p.p.m. level or between the two higher levels of treatment. At 400 and 200 p.p.m., there was approximately 33% and 25% control, respectively, relative to infection on fruit dipped in water plus wetter only.

In another experiment, two levels of antibiotic — 200 and 400 p.p.m. — were compared with water as a post-inoculation treatment, carried out immediately or after various incubation periods. Experimental details were similar to those in the previous experiment except that after inoculation, some stems were incubated at 83-85°F. for 3 or 9 hours in unperforated plastic bags prior to treating. The results of this experiment, and of two similar ones in which only 400 p.p.m. of Nystatin was tested are summarized in Appendix Asst. Path. 1. For each experiment, an analysis of variance was performed on the angular transformations of the recorded data. Over all incubation periods tested, the incidence of infection on Nystatin-treated fruit was significantly lower ($P < 0.001$) than that on water-dipped controls: however, in experiment 1, there was no significant difference between the two levels of antibiotic. It is seen that 400 p.p.m. Nystatin effected approximately 60%, 45% and 80% control, respectively: at 200 p.p.m. there was approximately 50% control.

The effect of incubation period on Nystatin control was investigated further. Fruit was inoculated and then incubated at 85°F for 0, 8, 16, 24, 32 or 40 hours before being treated. For each type of treatment, i.e., dipping in water or Nystatin, 7 replicate stems were inoculated at staggered intervals in order to include all incubation periods on each stem. Data obtained after cold storage and ripening are summarized in Appendix Asst. Path. 2. There was good control of infection by Nystatin when the incubation period did not exceed about 16 hours. Longer incubation resulted in a marked decrease in control. Analysis of the transformed data has shown that there is no significant difference between the data for treated and control fruit that was incubated for 32 or 40 hours. In these cases it must be concluded that there was no control of infection. Histological evidence suggests that, after about 30 hours incubation, the fungus may have penetrated the tissues to such an extent that it escapes antibiotic action. Under commercial conditions, therefore, it would be desirable to minimize the interval between harvesting and treatment with Nystatin.

An experiment was set up to compare the effect of Nystatin on three inoculation types viz. bruizes, light scratches or deep scratches. Dipping in water, 200 or 400 p.p.m. Nystatin was carried out after 3 hours' incubation. A randomized lay-out, with 5 replicate stems inoculated so as to provide a maximum possible number of 75 lesions for each treatment combination, was employed: all inoculation types were included on each stem. The results are shown in Appendix Asst. Path. 3. Statistical analysis of the transformed data once more showed a highly significant reduction ($P<0.001$) of infection due to Nystatin: there was no significant difference between the data obtained from the two concentrations of antibiotic. The variance ratio for inoculation type/error was also significant at the 0.1% level and, from Appendix Asst. Path. 3, it is seen that large, deep scratches are more conducive to infection than superficial scratches or bruises. There was poor control of infection that originated in large scratches; it is possible that spores had lodged in a relatively deep-seated position in the mutilated tissues and so avoided antibiotic action. General experience has indicated that the majority of natural infections are more superficial than

those induced experimentally, so that under commercial conditions reasonable control might be anticipated.

It was considered desirable to investigate possible effects on Nystatin control of different post-treatment exposures to tropical temperatures. Fruit was inoculated and dipped in water or Nystatin (200 or 400 p.p.m.) after 3 hours incubation. Each stem was then enclosed in a perforated 'Polythene' bag and stored at field temperatures (83°-86°F.) for a chosen interval before transfer to the cold store (55°F.). The experiment was recorded when ripening was complete and the data obtained are given in Appendix Asst. Path. 4. The results show that exposure of treated fruit to tropical temperatures for 7-14 hours before cold storage does not markedly affect the efficiency of Nystatin in controlling infection. This is of considerable practical importance since, under prevailing conditions in Jamaica, fruit may have to remain on the quay-side for several hours after Nystatin treatment before being transferred to refrigerated ships' holds.

Further experiments were designed to test Nystatin against naturally occurring **Gloeosporium** infections. Several stems were harvested from one field and transported over a short distance in trucks lined with banana leaf-trash. They were then segregated at random into two groups, one of which was dipped in Nystatin (400 p.p.m.) and the other in water. After cold storage and ripening in the normal manner, the numbers of fingers with one or more lenticular anthracnose lesions present were recorded. Data obtained from two lots of fruit are shown in Appendix Asst. Path. 5. Although there was a relatively low incidence of infection on control fruit, the results from both experiments suggest that Nystatin caused some reduction of disease.

In the experiments described above there was no evidence that Nystatin was phytotoxic. However, at 400 p.p.m., there was a slightly slower rate of ripening compared with water-dipped controls. This sometimes resulted in fruit requiring an extra 24 hours to attain full maturity. There was no apparent effect on ripening behaviour using 200 p.p.m. Nystatin. In several shipping trials, a post-harvest fruit-dip treatment with Nystatin (200-400 p.p.m.) effected 40-70% control of anthracnose.

B. Finger-Stalk Rot

Finger-stalk rot, commonly referred to within the banana industry as 'Santa Marta stem-end rot', has been described by Wardlaw (1935). When a finger is forced towards or away from the main-stalk, or twisted, the strain imposed on the relatively slender finger-stalk may result in tissues being bruised, if not ruptured. On harvested Jamaican bananas, finger-stalk injury usually takes the form of a transverse creasing or notching. Infection of wounds by various fungi, in particular **G. musarum** and **Fusarium** spp. (Meredith, 1958), is followed by rotting of the stalk. At the time of discharge in the United Kingdom, finger-stalk rot may be so advanced that it is difficult to handle fruit without causing 'finger-drop'. Further 'dropping' occurs in the ripening room where the rate of rotting increases under temperature conditions more favourable for fungal growth (65-75°F. as opposed to 53-56°F. inside the ship's hold). Tomkins (1931) considered 'finger-drop' to be the most important source of wastage of Brazilian fruit of the 'Cavendish' variety: sometimes this would appear to be true for Jamaican 'Lacatan' bananas.

Investigations are in progress in an attempt to find suitable chemicals for use in controlling finger-stalk rot. Preliminary work indicates that Nystatin is ineffective. Sodium salicylanilide ('Shirlan' WS) has shown some promise but further trials are necessary before the compound is used on a commercial scale.

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APPENDIX

Phys. 1. **EFFECT OF GIBBERELLIC ACID ON BANANA SUCKERS**

Layout: 3 Randomised Blocks, 8 Treatments

Treatments:

A. 0.875 g. GA applied in 300 g. Lanolin paste
B. 0.375 g. GA „ „ „
C. 0.0375 g. GA „ „ „
D. 0.875 g. GA applied in 5 ml. mist spray
E. 0.375 g. GA „ „ „
F. 0.0375 g. GA „ „ „
G. 1 minute dip in 100 ppm. GA solution
H. Control — no treatment.

All suckers allowed to remain in an open shed for 24 hours after treatment before planting.

Phys. 2. **PRUNING TRIAL 3**

Layout: 4 Randomised Blocks, 3 Main Treatments, 2 Sub-Treatments. Subplot size: 6 mats.

Treatments:

1. First sucker selected as follower
2. April and August suckers selected
3. Suckers selected at bulling.

Sub-Treatments:

A. Unwanted suckers removed monthly
B. Unwanted suckers removed only at time of selection.

Treatment	Mean no. of suckers/mat	Mean yield/mat		
		Stems	Counts	Grading
1A	20.7	1.7	1.49	88%
B	14.2	1.3	1.24	95
2A	23.3	1.5	1.47	98
B	12.3	1.6	1.58	99
3A	19.0	1.6	1.45	90
B	7.3	1.4	1.19	85
LSD (P = 0.05)	2.8			

Phys. 3. **OPENHANDEDNESS FIELD EXPERIMENT 4**

Layout: 4 Randomised Blocks, 4 Treatments
Subplot size: 24 mats

Duration: Plant crop only

Treatments

1. Standard estate practice 2 oz. Sulphate of Ammonia monthly — control
2. Ammonium Sulphate Nitrate equivalent to the Sulphate of Ammonia of treatment 1 on the same schedule
3. Sulphate of Ammonia 4 oz. monthly up to end of November
4. Ammonium Sulphate Nitrate equivalent to Sulphate of Ammonia of treatment 3 on same schedule.

Phys. 4. **PREMATURE YELLOWING — ST. THOMAS**

Layout: 8 Randomized Blocks, 3 Treatments, 3 Sub-treatments.
Subplot size: 9 mats.

Treatment: Nitrogen Source

A. Sulphate of Ammonia — 6 cwt/acre/annum
U. Urea — 2½ cwt/acre/annum
S. Nitrate of Soda — 7½ cwt/acre/annum

Sub-treatment: Frequency of application of Potash totalling 6 cwt/acre/annum Muriate of Potash

1. In 2 applications
2. In 4 applications
3. In 8 applications

Leaf Analysis (% Dry Matter)

Treatment	1		2		3		Mean	
	N	K_2O	N	K_2O	N	K_2O	N	K_2O
A	3.04	3.14	3.02	3.22	2.98	3.26	3.01	3.21
U	3.02	3.28	2.95	3.25	3.04	3.29	3.00	3.27
S	2.88	3.16	2.92	3.33	2.87	3.42	2.89	3.30
Mean	2.98	3.19	2.96	3.27	2.96	3.32	2.97	3.26
					LSD (P = 0.05)		0.02	0.03

Chem. 1.

BANANA FIELD SURVEY
(Fontabelle Clay)

Determination	Depth	GOOD FIELDS Range	GOOD FIELDS Mean	MEDIOCRE FIELDS Range	MEDIOCRE FIELDS Mean	Significant Difference Between Means
pH	0–9"	6.3 – 8.3	7.9	7.3 – 8.4	7.8	—
	9–18"	7.1 – 8.3	8.0	6.8 – 8.4	7.9	—
Phosphate (ppm)	0–9"	7 – 292	56	16 – 230	46	—
	9–18"	9 – 376	40	12 – 376	53	—
Potash (ppm)	0–9"	141 – 550	317	143 – 525	297	—
	9–18"	112 – 550	286	118 – 549	288	—
% Sand (1.0 mm – 0.05 mm)	0–9"	10 – 53	27	14 – 39	22	P (0.01)
	9–18"	14 – 53	26	12 – 32	21	P (0.01)
% Conventional Silt (0.05 mm – 0.005 mm)	0–9"	16 – 36	25	16 – 32	25	—
	9–18"	18 – 30	24	18 – 30	25	—
% Conventional Clay (0.005 mm.)	0–9"	29 – 68	49	36 – 66	64	P (0.01)
	9–18"	28 – 63	50	37 – 67	55	P (0.01)
% Finer Clay (0.002 mm.)	0–9"	22 – 65	43	32 – 62	48	P (0.05)
	9–18"	25 – 57	44	34 – 61	49	P (0.01)
Moisture Equivalent %	0–9"	32 – 57	40	36 – 53	44	P (0.01)
	9–18"	30 – 49	41	35 – 57	45	P (0.01)
Organic Matter %	0–9"	0.80 – 2.27	1.40	0.80 – 2.68	1.45	—
	9–18"	0.64 – 1.62	1.09	0.51 – 1.55	1.11	—

Chem. 2. **DRYING TEMPERATURE OF SOIL SAMPLES**

(AVAILABLE POTASH)

A. Mean K_2O (p.p.m.)

Soil type	Depth	Air Drying for 3 days	Drying at 40°C. for 1 day	Drying at 60°C. for 1 day	C.V.	Significant Difference P (0.01)
Agualta Sandy Loam No. 24	0–9"	62.8	49.1	84.0	5.7	5.3
	9–18"	40.8	36.0	68.0	5.5	3.8
Water Valley Silty Clay No. 21	0–9"	168.5	162.9	265.5	1.5	4.2
	9–18"	179.6	186.1	294.4	1.9	5.8

B. Mean K_2O (p.p.m.) and Mean % Moisture Content

Depth	Soil type No. 24				Soil type No. 21			
	0–9"		9–18"		0–9"		9–18"	
Drying Temp.	K_2O	% Moist.	K_2O	% Moist.	K_2O	% Moist.	K_2O	% Moist.
Air	62.8	3.0	40.8	2.6	168.5	8.7	179.6	8.7
40°C	49.1	4.6	36.0	3.5	162.9	10.9	186.1	8.4
60°C	84.0	2.3	68.0	1.9	265.5	6.6	294.4	6.8

Anal. 1. **ANALYSES**

Specimens Received		No. of Determinations	
(a) Banana Tissue, Leaves	976	Nitrogen	2264
		Phosphate	2110
		Potash	1972
		Calcium	1677
		Magnesium	265
		Dry Matter	907
(b) **Fertilizers & other samples**			
Mixtures	6	Moisture	22
Humber fish manure ..	1	Nitrogen	30
Bat manure	1	Phosphate	37
Coir dust	3	Potash	30
Humus	4		
Total no. rec'd.	991	Total determinations done	9314

Anal. 2. **AVERAGE MONTHLY VALUES OF %N, P_2O_5, K_2O IN LEAVES 2 AND 3 FROM SITES OF GOOD AND POOR PRODUCTIVITY**

NITROGEN

	Leaf 2					Leaf 3			
Months	'Poor' (west.)	'Poor' (east.)	'Good' A	'Good' B	Months	'Poor' (west.)	'Poor' (east.)	'Good' A	'Good' B
Jan.	2.53	2.23	3.15	3.39	Jan.	2.66	2.15	3.26	3.34
Feb.	1.95	2.47	2.85	3.05	Feb.	2.39	2.92	2.75	3.14
Mar.	1.99	2.13	2.81	3.16	Mar.	2.11	2.16	3.08	3.14
Apr.	1.87	2.03	2.45	2.77	Apr.	1.82	1.06	2.38	2.59
May	1.80	1.69	2.62	2.77	May	1.94	1.72	2.70	2.61
June	1.53	2.44	2.48	2.80	June	1.29	2.49	2.45	2.87
July	2.17	2.37	2.81	2.87	July	2.33	2.42	2.90	2.95
Aug.	3.56	3.04	3.13	3.45	Aug.	3.43	3.01	3.08	3.33
Sept.	2.96	2.78	3.24	3.53	Sept.	3.16	3.07	3.29	3.66
Oct.	2.73	2.30	3.25	3.50	Oct.	2.73	2.87	3.51	3.63
Nov.	3.10	3.10	3.20	3.80	Nov.	2.89	3.18	3.03	3.85
Dec.	2.90	2.81	3.41	4.04	Dec.	2.93	3.02	3.57	4.08

PHOSPHATE

	Leaf 2					Leaf 3			
Months	'Poor' (west.)	'Poor' (east.)	'Good' A	'Good' B	Months	'Poor' (west.)	'Poor' (east.)	Good' A	'Good' B
Jan.	0.91	0.74	0.54	0.55	Jan.	1.01	0.71	0.52	0.53
Feb.	0.71	0.82	0.51	0.45	Feb.	0.63	0.91	0.44	0.42
Mar.	0.68	0.73	0.52	0.61	Mar.	0.65	0.67	0.51	0.57
Apr.	0.48	0.48	0.46	0.49	Apr.	0.43	0.45	0.46	0.50
May	0.57	0.48	0.49	0.52	May	0.55	0.40	0.47	0.47
June	0.68	1.03	0.58	0.55	June	0.68	1.05	0.50	0.48
July	0.53	0.76	0.64	0.63	July	0.55	0.82	0.65	0.50
Aug.	0.57	0.84	0.52	0.52	Aug.	0.52	0.88	0.48	0.49
Sept.	0.47	0.52	0.48	0.49	Sept.	0.42	0.52	0.46	0.46
Oct.	0.59	0.46	0.47	0.51	Oct.	0.56	0.41	0.47	0.49
Nov.	0.97	0.42	0.54	0.48	Nov.	0.89	0.39	0.52	0.45
Dec.	0.55	0.41	0.53	0.55	Dec.	0.50	0.40	0.47	0.51

Anal. 2. (Continued)

POTASH

Months	Leaf 2 'Poor' (west.)	Leaf 2 'Poor' (east.)	Leaf 2 'Good' A	Leaf 2 'Good' B	Months	Leaf 3 'Poor' (west.)	Leaf 3 'Poor' (east.)	Leaf 3 'Good' A	Leaf 3 'Good' B
Jan.	4.27	4.42	4.53	4.11	Jan.	3.94	3.89	4.01	4.25
Feb.	4.59	4.69	4.09	4.15	Feb.	3.96	4.47	4.09	3.61
Mar.	4.05	4.89	3.62	4.02	Mar.	4.18	4.30	3.79	3.84
Apr.	3.37	3.93	3.57	3.64	Apr.	4.14	4.10	3.28	3.69
May	4.33	4.34	3.56	3.81	May	3.58	4.06	3.38	3.29
June	4.70	4.42	3.97	4.55	June	4.36	3.91	3.81	4.54
July	4.49	4.28	4.02	4.43	July	4.20	3.95	3.82	4.16
Aug.	4.56	4.75	4.06	3.63	Aug.	4.06	4.09	3.89	3.53
Sept.	4.26	4.08	3.66	3.82	Sept.	4.18	4.03	3.49	3.48
Oct.	4.21	3.68	3.78	4.37	Oct.	3.93	3.62	3.89	4.31
Nov.	4.63	4.41	4.47	4.27	Nov.	4.29	3.96	4.16	4.47
Dec.	4.67	4.31	4.73	4.86	Dec.	4.38	3.95	3.90	4.71

Anal. 3. RESULTS OF SOIL ANALYSES AT SITES UNDER INVESTIGATION

	pH	Av. P_2O_5 ppm.	Av. K_2O ppm.
'Poor' area, western	7.1	57	325
'Poor' area, eastern	7.5	42	136
Good area A	5.1	34	188
Good area B	7.7	199	231

Agr. 1. SUCKER TIMING OBSERVATION

	May 1957	August 1957	December 1957	March 1958
Mean altitude (x)	623.4	623.4	623.4	623.4
„ months to shooting (y)	18.3	20.3	20.7	20.0
Correlation coeff.	.7649^{xxx}	.7872^{xxx}	.7941^{xxx}	.7879^{xxx}
Regression „	.0036	.0045	.0044	.0035
t on „ „	8.256^{xxx}	9.146^{xxx}	9.186^{xxx}	9.211^{xxx}

$^{xxx} = P < 0.001$

Path. 1.

HIGH LEVEL AERIAL OIL SPRAYING

Mean Percentage Area of Leaf Spot

(on 8 youngest leaves)

ESTATE	Start Feb. 9 – 13	June 16 – 19	Aug. 12 – 13	Sept. 7 – 29	End Nov. 18 – 19
Portland A.	5.5	1.8	1.2	0.8	0.9
Portland B.	12.6	4.6	1.5	9.3	3.7
Bog Walk C.	3.9	2.2	2.5	3.3	0.9
St. Mary D.	1.6	0.0	0.0	0.0	0.0

Path. 2.

OIL PHYTOTOXICITY IN RELATION TO NUTRITIONAL STATUS OF BANANA PLANT

Layout. 2 Blocks of 3^3 Fertilizer Experiment. Single Plot = 8 mats.

Fertilizer Treatments.

N — Sulphate of Ammonia
P — Single Superphosphate
K — Muriate of Potash

0 — None
1 — ¼ lb, 3 times a year
2 — ½ lb, 3 times a year

Relative amount of flecking
(No fertilizer = 100%)

Test No.	I	II	III
N_0	100.0	100.0	100.0
N_1	56.9	78.5	92.8
N_2	50.1	77.1	76.3
Significance (P)	< 0.001	< 0.05	—

Test No.	I	II	III	Test No.	I	II	III
P_0	100.0	100.0	100.0	K_0	100.0	100.0	100.0
P_1	84.0	98.5	103.4	K_1	82.2	85.8	105.5
P_2	75.3	99.0	105.6	K_2	84.3	86.1	103.2
Significance (P)	—	—	—	Significance (P)	—	—	—

Path. 3. **LOW-VOLUME, WATER MISCIBLE FUNGICIDE SPRAYING TRIAL**

Layout. 3 Randomised Blocks. 6 Treatments. Plot Size 1 acre.
Spraying started 29/6/59. Records taken 23/3/60.

	Quantity applied per acre in 4 galls. water	Mean % area of leaf spot on 12 youngest leaves (per plant)
1. Schering Copper Oxychloride	4.7 lbs.	3.59
2. „ „ „	3.5 lbs.	3.69
3. „ „ „	2.3 lbs.	3.53
4. Cuprous oxide (Aerial Perenox)	4.0 lbs.	3.32
5. „ „ „ „	3.0 lbs.	3.55
6. „ „ „ „	2.0 lbs.	3.39
	Sign. Difference	—
	Coeff. Var.	7.1%

Path. 4. **NEMAGON TREATMENT OF BANANA HEADS AT TIME OF PLANTING**

Layout. 4 Randomised Blocks. 5 Treatments. Planted 19/7/58.

Treatments

A. Nemagon granules (10 g.) dusted in planting hole (mixed with 20 g. Gypsum)

B. „ „ (20 g.) „ „ „ „ „ „ 40 g. „

C. Nemagon, 75% Emulsifiable Concentrate (1 in 25) sprayed on to head in planting hole (approx. 100 ccs)

D. „ „ „ „ (1 in 50) sprayed on to head in planting hole (approx. 100 ccs)

E. None (Control).

Treatment	Root Disease Index No.	Ht. at shooting (inches)	No. weeks to shooting	Grade No. Hands
A.	4.45	98	42.7	7.31
B.	3.75	101	42.6	7.38
C.	4.15	99	42.1	7.47
D.	4.23	101	42.5	7.41
E.	6.75	99	42.5	7.29
Sign. Diff. P(0.05)	1.66	—	—	—
Coeff. Var.	23.2%	6.2%	25.8%	4.8%

Asst. Path. 1. **EFFECT OF NYSTATIN ON POST-HARVEST INFECTION BY G. MUSARUM: PERCENTAGE NUMBERS OF LESIONS (OUT OF 120) DEVELOPED FOLLOWING INOCULATION AND TREATMENT AFTER VARIOUS INCUBATION PERIODS**

Experiment	Treatment	Incubation period (hours)			Mean
		0	3	9	
1	Water (controls)	87.5	83.8	52.9	74.8
	Nystatin (200 p.p.m.)	52.0	30.2	25.4	35.9
	Nystatin (400 p.p.m.)	38.5	21.8	21.8	27.4
2	Water (controls)	64.6	63.9	49.3	59.3
	Nystatin (400 p.p.m.)	17.8	4.7	4.0	8.8
3	Water (controls)	73.3	82.4	76.6	77.4
	Nystatin (400 p.p.m.)	52.4	35.8	32.5	40.2

Asst. Path. 2. **NUMBERS OF LESIONS DEVELOPED (OUT OF 70) ON FRUIT INOCULATED WITH G. MUSARUM AND TREATED WITH NYSTATIN OR WATER AFTER VARIOUS INCUBATION PERIODS**

Treatment	Incubation period (hours)						
	0	8	16	24	32	40	Mean
Nystatin (400 p.p.m.)	11	6	24	36	40	46	27.2
Water (controls)	62	44	56	59	50	54	54.2

Asst. Path. 3. **NUMBERS OF LESIONS DEVELOPED (OUT OF 75) ON BANANAS INOCULATED IN DIFFERENT WAYS WITH G. MUSARUM AND TREATED WITH NYSTATIN.**

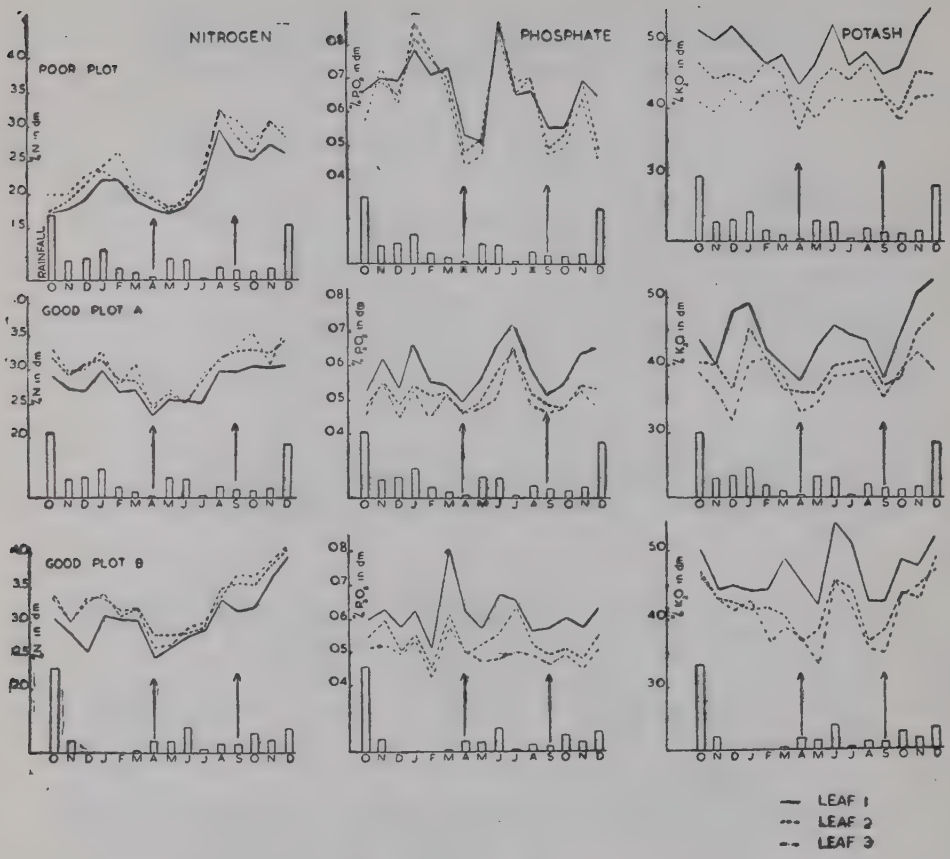
Treatment	Inoculation type			Mean
	Bruise	Superficial scratch	Deep scratch	
Nystatin (400 p.p.m.)	6	17	55	26.0
Nystatin (200 p.p.m.)	4	9	51	21.3
Water (controls)	10	55	70	45.0
Mean	6.6	27.0	58.7	

Asst. Path. 4. EFFECT OF VARIOUS PERIODS OF EXPOSURE TO TROPICAL TEMPERATURES, PRIOR TO REFRIGERATION, ON CONTROL OF G. MUSARUM BY NYSTATIN: NUMBERS OF ANTHRACNOSE LESIONS DEVELOPED (OUT OF 120) ON 6 REPLICATE STEMS

Treatment	Storage period at tropical temperature (hours)			
	0	7	14	Mean
Nystatin (200 p.p.m.)	8	5	4	5.7
Nystatin (400 p.p.m.)	6	3	4	4.3
Water (controls)	55	43	55	51.0
Mean	23.0	17.0	21.0	

Asst. Path. 5. EFFECT OF NYSTATIN TREATMENT ON THE INCIDENCE OF NATURAL INFECTION OF BANANAS BY G. MUSARUM

	Treatment	Total no. fingers examined	No. fingers with anthracnose	Percentage diseased fingers
Exp. 1	Nystatin (400 p.p.m.)	1098	9	0.8
	Nystatin (200 p.p.m.)	1220	11	0.9
	Water (controls)	987	32	3.2
Exp. 2	Nystatin (400 p.p.m.)	573	24	4.2
	Water (controls)	525	64	12.2



MONTHLY VARIATION OF N P K IN LEAVES 1-3 OF STAGE 2 LACATAN BANANA PLANTS OCT. '58 - DEC. '59 FROM SITES OF GOOD AND POOR PRODUCTIVITY

STAFF AT 31st DECEMBER, 1959

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